SCIENCE ABSTRACTS.

Section A.—PHYSICS.

MARCH 1911.

GENERAL PHYSICS.

293. *Ott's Compensating Planimeter.* (Mech. Eng. 27. pp. 57-61, Jan. 20, 1911.)—A planimeter without a compensating arrangement can only give accurate results if the axis of the integrating wheel is exactly parallel to the mathematical tracing arm of the instrument, *i.e.*, the line drawn from the centre of the joint to the tracing point. In Ott's instrument the polar arm and the tracing frame are separate pieces, connected when in use by a ball-and-socket joint. The tracing frame rests on three points, viz., the integrating wheel, a supporting wheel on the opposite side of the socket, and with its axis at right angles to that of the integrating wheel, and a small peg close to the tracing point; it is thus always in equilibrium. With only ordinary care the ball pin and the socket in the frame cannot be damaged, and, moreover, this arrangement gives the planimeter a great range of tracing. The principal advantage, however, is that every reading can be checked by a compensating measurement. The planimeter is placed on the figure to be measured, with the pole to the right (say) of the tracer arm, and the outline of the figure is traced clockwise, the reading being noted. Without in any way shifting the pole the frame is then swung round the joint till it stands symmetrically to the first position, and the measurement is repeated. The mean of the results obtained in the two positions gives the correct area of the figure, even if the results of the two operations differ somewhat in consequence of possible non-parallelism of the axis of the roller with the tracer arm. The latter part of the paper deals with various practical applications of the instrument. A. W.

294. *Lilly's Torsion Testing Machine.* (Engineer, 111. p. 175, Feb. 17, 1911.)—In connection with the theory of fatigue and breakdown of metals the value of a shear test is now becoming generally recognised. The torsion testing machine described in this article has been designed by W. E. Lilly, and it has the advantage that autographic diagrams may be taken under either direct or alternating stress conditions. The reader is referred to the original for details of construction and arrangement of the apparatus. The stress-strain diagrams are taken off with a pencil. Some of these are given; they show quite clearly the raising of the yield-point, both under direct and reverse stress; after the fifth or sixth reversal the yield-point becomes ill-defined as the tests proceed. It is claimed for the machine that there is but little of the dynamic action which has been detected even in Wöhler's apparatus. Some people hold that such dynamic action is in itself sufficient to explain the apparent fatigue of metals when subjected to a repeated or varying load in the testing machine. [It should be noted that this dynamic action upon the material takes place in practice in nearly all conditions of varying or alternating stress.] The theory of fatigue requires a specimen with a direct strength of *t* to break under a load of ⅓*t* if the load alternates from a plus value to an equal minus value. A specimen having a breaking strength of 57,600 lbs. per sq. in. under direct torsional stress, broke at 48,000 lbs. in Lilly's machine. If the theory of fatigue be accepted, it is difficult (says the article) to explain why the above specimen broke at 48,000 lbs., and not at 19,200 lbs. Obviously more tests and further data are required before any very sweeping statement can be made upon this subject of relation of dynamic effect to strength of materials. C. A. M. S.

295. *Testing of Metals by the Abatement of Vibratory Movements.* **A. Boudouard.** (Bull. Soc. d'Encouragement, 114. pp. 545–574, Dec., 1910. Comptes Rendus, 152. pp. 45–47, Jan. 3, 1911.)—The fracture of a metal can be effected not only by one application of the ultimate stress, but also by the continued application of considerably smaller stresses. A bar of the metal under test, 1 cm. × 0·5 cm., is clamped at one extremity so that its free end is 27 cm. long and caused to vibrate electromagnetically very much in the same manner as the interrupter of an electric bell. The free end carries a small mirror illuminated by a beam of light so that the vibrations can be observed on a graduated scale or recorded autographically by means of a photographic recorder. About 30 double vibrations per sec. are made, and the displacement of the free end of the bar is about 3·5 to 4 cm., corresponding to an angle of 6° to 7°. Preliminary experiments with a commercial steel of good quality showed that in the natural state the bar broke after 12½ hours (1,350,000 vibrations); after annealing for 10 hours at 850° C. it broke after 4½ hours (486,000 vibrations); and after quenching in cold water from 1000° C., after ½ an hour (54,000 vibrations). Fracture always occurs near the clamp, and is announced by a decrement in the vibrations, and examination of the fractured surfaces showed parallel zones of different-sized grains indicating the phenomenon of tearing. Further experiments were then carried out on puddled iron, an extra soft basic Martin steel and three Creuset steels containing respectively 0·3, 0·6, and 1·0 per cent. carbon, the metals being studied in the natural, annealed, and hardened states. The results, however, were not so promising as expected, and it does not appear that metals undergo readily-observed transformations before rupture. Under the same conditions of experiment closely agreeing duplicate results are readily obtained; two steels of the same composition but of different origin gave durations of 12½ and 13½ hours respectively. It appears, therefore, that the method can be successfully employed in determining resistance to alternating stresses. In semi-hard and hard steels the number of vibrations necessary for fracture are inversely proportional to the carbon-content, but puddled iron is much more resistant than soft Martin steel. Under the test

0·8 per cent. carbon steels show no sensible differences in the annealed and hardened states, but with high-carbon steels, hardening considerably diminishes the time necessary for rupture. Restoring hardened steel considerably improves its properties, *e.g.*, a 1 per cent. carbon steel broke after 8 hours 25 min. in the annealed state, after 5 min. in the hardened state; but after restoration it was still unbroken after 26 hours 30 min. In addition to the parallel zones of different-sized grains the fractures show short, irregular, shear-lines perpendicular to the edges of the section. Mechanical tests made on the broken bars showed that the vibratory movements considerably increased the elastic limits of the puddled iron and soft steel.

F. C. A. H. L.

296. *The Optical Determination of Stress.* **E. G. Coker.** (Phil. Mag. 20. pp. 740–751, Oct., 1910. Paper read before the British Assoc. at Sheffield.) —Brewster suggested the use of polarised light on glass models of arches to investigate changes in their optical properties, and hence to deduce the strains in them. Glass is expensive, however, and models have to be thick and stressed nearly to fracture, while "xylonite" has most of the desirable properties of glass and may be easily cut to shape; it may, further, be stressed to 4000 lbs. per sq. in. without damage. If glass or xylonite be stressed it behaves as a double refractor and decomposes a beam of plane-polarised light into plane-polarised rays parallel and perpendicular to the axes of principal stress, their relative retardation depending on the indices of refraction of the rays and the thickness of the plate. Experiments show that the differences of the indices vary as the difference of principal stresses in the plate, the constant of variation, C, being sensibly constant for all lights used. The results for an eccentrically loaded tension piece and for a hook are given, and are worked out and plotted. [See also next Abstract.]

C. A. M. S.

297. *Photo Elasticity.* **E. G. Coker.** (Engineering, 91. pp. 1–4, Jan. 6, 1911.)—[For a more complete description of the theory see preceding Abstract.] Experiments were carried out on specimens of xylonite of various shapes. With monochromatic light, for specimens of equal thickness the greater the stress in the specimen the higher is the observed colour in the scale, so that the colour is a measure of the stress at any point. Unfortunately, at points in the specimen where the directions of the principal planes of stress are the same as those of the nicols the light vibrations are not changed by the specimen, and are all cut out by the analyser, so that along lines joining these points dark bands, which mask the colour effects, are produced. This may be avoided by using circularly polarised light, the conversion from plane-light being effected by means of a quarter-wave plate placed at the polariser and set with its axis at 45° to the plane of the nicols. In front of the analyser another plate re-converts the ray into plane-polarised light again. With circularly polarised light only the colours of Newton's scale are produced. In order to investigate the magnitude of the stresses in, say, a beam, two specimens of equal thickness, one a tension specimen on which the stress can be varied and the other a stressed beam, are placed side by side in the path of the circularly polarised light. In the tension specimen a uniform colour is produced, while in the beam a series of coloured bands, ranging in these tests from black at the neutral axis through grey, yellow and red to blue at the outer fibres, are observed. In order to find the stress at any point in the beam, the tension specimen is loaded until its colour matches that of the point under consideration. Then the stress at the point in the beam is the same as that in the tension specimen, which is known. When the stresses at various points on a cross-section have been found and plotted on a diagram, results practically identical to the ordinary beam theory are obtained. This shows that the optical method is to be relied upon and may safely be used to investigate the stresses in cases where theoretical methods cannot be applied or are not to be relied on. The appearance of various specimens such as a loaded hook, circular ring, &c., is shown in a series of eighteen coloured plates. In these the points of max. stress may easily be picked out owing to their blue colour. In order to completely determine the stresses in any body the magnitudes and directions of the principal stresses must be known. Their magnitudes may be determined from the colour produced, as has been indicated, using circularly polarised light. To determine the directions of the planes of principal stress, plane-polarised light is used. When the nicols are set with their principal planes, say, vertical and horizontal, two dark bands are produced, whose positions are plotted on a diagram. At all points on the bands it is known that the directions of the principal planes are the same as those of the nicols, *i.e.*, vertical and horizontal. The nicols are then set with their principal planes at some other angle, still keeping them at right angles to each other, and a fresh pair of dark bands plotted. Proceeding in this way, the directions of the principal planes may be found for any point in the specimen. Although the experiments cannot be carried out on the materials usually used for construction, it is probable that they give a very good approximation to the internal conditions of such materials when loaded. C. A. M. S.

298. *Researches on the Elasticity of Materials.* **C. A. M. Smith.** (Eng. Rev. 24. pp. 1-10, Jan., 1911.)—For research purposes it is necessary to measure the elastic limit, and the max. stress at this point, while in commercial testing the stress at the yield-point is the more useful figure. In perfectly homogeneous material loaded axially the elastic limit and yield-points coincide, but in most tensile tests there is some divergence between these figures, due partly to the inhomogeneity of the material, and partly to eccentricity of loading, which brings about an "elastic limit effect" and a "time effect" [see Abstract No. 875 (1910)]. The degree of eccentricity of loading depends on the design of the testing-machine and the method of gripping the specimen. During a tensile test the distribution of stress varies—a test using specimens with screwed ends and spherical seats showed a ratio of (max.)/(mean) stress equal to 1·45 at a load of 2 tons, while at 8 tons the ratio was 1·15. This ratio varies from test to test and is particularly noticeable when using V-grips. The result of the uneven distribution of stress is that the stress recorded for the elastic limit has too low a value, which may throw some light on the difference in elastic properties observed by static and dynamic tests. Some materials are very much affected by the time elapsing between the increments of load, and it is probable that this phenomenon influences the determination of the elastic limit. Elastic extension probably depends on molecular attractions, themselves depending on some physical constant of the chief constituent. Slipping, the ultimate cause of breakdown, depends on the physical condition of the molecules and internal friction, and the true elastic limit is the point at which the internal forces are in equilibrium with the "sticktion" of the molecules. In homogeneous materials the point is marked by a sudden slip throughout the entire specimen, giving rise to a well-defined yield-point, while in non-homogeneous

material the "sticktion" is not constant and slip occurs by degrees and gives rise to a veiled yield-point. Recent tests by the author show that in the case of mild steel the slip becomes very small after a few days and the extension again becomes elastic, and so on up to elastic breakdown. F. C. A. H. L.

299. *Stresses in a Thick Hollow Cylinder subjected to Internal Pressure.* **L. B. Turner.** (Cambridge Phil. Soc., Trans. 21. No. 14. pp. 377–396, Sept. 12, 1910.)—On the assumptions of isotropy of the steel, of the accuracy of the shear theory of elastic failure, and of the complete plasticity of yield, the usual formulæ are first derived, namely, $R_1 = P[a^2/(b^2 - a^2)](1 - b^2/r^2)$, $R_2 = P[a^2/(b^2 - a^2)](1 + b^2/r^2)$; R_1, R_2 are radial and hoop stresses at radius r; a and b are internal and external radii. Hence safe pressure P to cause failure of inner skin of fresh tube is $P = S(b^2 - a^2)/b^2$, where S = shear strength. When P exceeds this value failure occurs, and a plastic region, under uniform shear S, is set up as P increases. The ratio (safe repeated pressure)/(primitive-elastic-limit pressure) increases from unity for thin tubes to 2 for $b/a = 2{\cdot}2$, after which it is constant at 2. The primitive elastic limit pressure increases very little after $b/a = 3$, which is the limiting useful thickness. The limiting increase of strength by *any* treatment is 2 : 1 given by P/S = 2. A suggested application of the theory is to treat guns by internal fluid pressure, in place of, or in combination with, existing methods, to produce an initial stress-distribution so as to ensure a more uniform resultant stress when a shot is fired. In modern big guns the greatest ratio b/a is 3 or 4 and tubes are commonly of steel with elastic limit 30 tons per sq. in. Hence the internal pressure P required to prepare the gun is $2S(b^2 - a^2)/b^2 = 27$ tons per sq. in.; this pressure is quite manageable. If the hard liner cannot stand the overstraining, it can be removed and afterwards replaced as in wire-wound guns. To allow for the varying thickness in a gun, the pressure may be applied with different intensities on different sections between two movable pistons. C. A. M. S.

300. *Comparison of Tensile, Impact-tensile, and Repeated Bending Tests on Steel.* **B. Blount, W. G. Kirkaldy, and H. R. Sankey.** (Inst. Mech. Engin., Proc. 2. pp. 715–753; Discussion and Communications, pp. 754–772, May, 1910. Engineering, 89. pp. 727–731, June 3, 1910. Engineer, 109. pp. 575–577, June 3, and pp. 598–600, June 10, 1910.)—The steels tested comprised thirteen varieties in commercial use. Chemical analyses and photomicrographs were made from each steel used. The static tensile tests were carried out in the usual manner, and the elastic stress was particularly noted. In the impact tests round specimens 0·357 in. diam. were broken in direct tension. This form of specimen was adopted because in notched test-pieces the slightest weakness in the microstructure at the bottom of the notch seriously impairs the strength. The specimen, to the ends of which are attached a crosshead and a weight, is allowed to fall freely through a height adjustable up to 40 ft., when the crosshead is arrested by an anvil containing a hole large enough to allow the specimen and tup to pass through. The height of fall is arranged so as to break the specimen at the first blow. The velocity of the tup (after fracture) is found by the aid of an electric timing device connected to an automatic recorder. By this means the kinetic energy remaining in the tup can be accurately computed. The repeated-bending machine takes a specimen 4 in. long by ⅜ in. diam., which is bent backwards and forwards by means of a hand-lever until rupture occurs. The number of bends and the bending effort are automatically recorded, and the area of the diagram obtained gives the total energy expended on the test-piece. With regard to comparisons between the three methods of testing, the ultimate strength can be obtained from the impact tensile tests by dividing the energy absorbed by the elongation. The figures thus obtained agree proportionately with those of the static tests, but the former are higher. In comparing repeated-bending tests with static tests it is clear that the initial bending effort and the yield-stress are connected, as also are the max. bending effort and the ultimate stress. The number of bends is a measure of the ductility, and was found to vary with the product of the elongation and the contraction of area in the other two tests. In curves plotted with the percentages of carbon as abscissæ, and the various properties such as bending effort, yield-stress, &c., as ordinates, the relation between the three methods of testing is well illustrated, as the curves run more or less parallel to each other and have corresponding elevations and depressions. In considering the energy absorbed per cub. in. for fracture, it must be noted that in both bending and static tests the metal in which the bulk of this energy is absorbed is concentrated near the fracture. When due corrections are made it is found that a bending specimen absorbs nearly twice as much energy as a tension specimen. In the *discussion*, C. H. **Wingfield** was of opinion that the time effect in impact tests might be important, as in some cases the final velocity of the tup was greater, thus causing a quicker fracture. J. O. **Arnold** thought that the angle through which the specimens were bent was excessive, as he had used an angle of 7° with success. C. E. **Stromeyer** communicated a formula establishing a relation between the chemical analysis and the ultimate strength. In reply the **Authors** stated that a large angle was chosen in the bending tests for the purpose of reducing the number of bends required. They were also of opinion that the ultimate strength of steel was influenced largely by the physical state of the metal, as well as by its chemical composition, so that any formula can only give approximate results. C. A. M. S.

301. *Bending Stresses in a Beam with varying Elasticity across the Section.* R. **Baumann.** (Zeitschr. Vereines Deutsch. Ing. 55. pp. 140-147, Jan. 28, 1911.)—The first half of the paper deals with the bending stresses in a beam when the elasticity varies across the section. It is assumed that sections which are plane before bending remain plane after bending, and that the stress-strain curves for the material under discussion are known for tension and for compression. The stresses are plotted for an actual section, a hyperbolic law of variation being assumed, and a method of approximation is elaborated whereby a mean curve is obtained which represents approximately the true stress variation, and is such that the areas of the stress diagrams on either side of the neutral axis are equal. The author then investigates the change of position of the neutral axis for various bending moments and the consequent changes of the other functions of bending, comparing them with the results on the assumption that the elasticity is constant. The second part of the paper investigates similarly the form of bending when the modulus varies, and finally the theory is applied to the case of a compound tube made up of materials of different elasticities.

C. A. M. S.

302. *The Stiffness of Guns.* H. J. **Jones.** (Engineering, 90. pp. 877-880, Dec. 30, 1910.)—Compares the solid and wire-wound types of modern 12-in. 50-calibre guns. The design of both guns is suitable for a muzzle velocity of 3000 ft./sec., with max. pressure of 20 tons and a muzzle pressure

of 7 tons per sq. in. The wire-wound gun considered is wired throughout its length; layers of wire vary from 16 at the muzzle to 80 over the chamber. The portion of the gun forward of the cradle is considered as a cantilever, and in the appendices there are investigations on the droop of the muzzle relative to the axis of the cradle; the effect of sunshine in modifying this droop; also the nature of the transverse vibrations of the muzzle on firing. With representative figures for modern well-designed 12-in. 50-calibre guns, the droop due to mere weight is about 4⅓ minutes of arc for the wire-wound, and 2⅓ minutes for the solid gun. The temperature strain can also cause a bend (in any direction) of from 2 to 8 minutes of arc. Therefore the wire-wound gun may have a total droop of about 7 minutes of arc when the uppermost portion of gun is nearest hottest portion; or 2 minutes when lowermost portion is hottest. With badly designed guns droop, due to lack of girder stiffness may reach 4 or 5 times the above values. In the case of built-up solid guns the max. droop due to weight and temperature strain will be about 5 minutes of arc, and the minimum less than 1 minute. With well-designed guns investigated the max. velocity from upward "whip" of the muzzle is about 12 ft./sec. with wire-wound, and 7 ft./sec. with solid gun. With a bad example of wire-wound gun the "whip" velocity may reach 50 to 60 ft. per sec. Apart from the inconvenience of this variable droop, since sights cannot be accurately set or tested against the last few feet of rifling, and it is difficult to set or test them against the axis of the bore at the breech, it is important to consider the effect of the "whip" on accuracy or consistency of shooting. Since period of oscillation has no connection with travel of projectile along the bore, the muzzle may be moving up or down or may be practically at rest at the instant when the projectile leaves the bore, and is receiving acceleration due to the muzzle-blast. The weight of charge is such that this effect is to give the projectile a probable increase of 50 ft. to 80 ft./sec. in velocity after it has left the rifling. The result of the various investigations is the conclusion that when the projectile leaves the gun it has a more or less systematic wobbly motion, which continues up to 500 yards, and probably to a considerably greater distance. Experiments on initial unsteadiness by means of cardboard screens seem to bear out the fact that initial unsteadiness does take place, but "it is not possible at present to say what proportion of this initial unsteadiness is due to eccentric engraving of the driving-band, or to the centre of gravity of the projectile being out of the axis of the figure." The author gives valid reasons why the whole subject merits attention. C. A. M. S.

303. *Investigations on Bearing-metals (White Metal).* **E. Heyn and O. Bauer.** (Königl. Materialprüfungsamt, Mitt. 29. 1. pp. 29–49, 1911.)—Tests were made on white metal used for bearings on the Prussian State Railways, specimens of the raw materials, ingots from which bearings are made, and finished bearings being examined. Analyses were made of chemical composition and microstructure, and tests of the malleability, compressive strength, and hardness. The major portion of the paper deals with the effects of repeated melting and of the addition of reducing agents. Fusion repeated five times reduced the percentage of Sn and Sb, and increased that of Cu; it produced little change in the crystalline structure and in the hardness, malleability, and compressive strengths; the last three were, however, raised considerably by rapid cooling, which consequently changes the properties of the metal for use in bearings. The fineness of the crystalline fracture was found to be a useful indicator for regulating the rate of cooling,

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provided the chemical composition is not changed too much, rapid cooling producing finer crystals; but a more accurate check is obtained from microphotographs. On the other hand, the fracture is not an accurate indicator of chemical change, and in some cases an analysis is necessary. Addition of Mg and Al as reducing agents raises the hardness slightly, but the effect on malleability depends on the rate of cooling. It was found that under the circumstances of these tests small quantities of Mg and Al will not produce appreciable changes in the properties of the metal. When Al was present as a reducer, excrescences of Al_2O_3 were observed, and it is not evident, without further research, whether these materials have any beneficial effect. Since repeated melting produces so little change in the chemical composition and the physical properties, the addition of reducing agents seems to be superfluous. It is concluded that in casting bearing-metal, excessive melting temperatures should be avoided and cooling should not be too slow. The paper is illustrated by a number of photomicrographs of metal after repeated meltings and varying rates of cooling. C. A. M. S.

304. *Tests of Rivet Steel for Gripping Power.* **C. Fremont.** (Genie Civil, vol. 57, Nov. 19, 1910. Eng. News, 65. p. 41, Jan. 12, 1911. Abstract, Mech. Eng. 27. pp. 141–142, Feb. 8, 1911.)—As a result of extended studies on riveted joints the author recommends that rivet steel should be tested for gripping power, which is dependent upon other factors than the tensile strength of the material, *e.g.*, the amount of contraction during cooling, &c. An ordinary carbon steel of 48,000 lbs. per sq. in. elastic limit gives a gripping force of 14,000–17,000 lbs. per sq. in., while a nickel chrome steel of 85,000–140,000 lbs. elastic limit has scarcely any gripping power. The machine designed for testing gripping power is simply a horizontal lever whose fulcrum is the rivet to be tested, all bearing faces being made of hardened-steel discs. By loading the free end of the lever and noting the load at which it begins to fall, a measure of the friction in the hinge, which is proportional to the gripping power of the rivet, is obtained. The rivet should afterwards be subjected to tensile and notched bending tests in order to get a complete record of the mechanical properties of the material. F. C. A. H. L.

305. *Test of a Reinforced Concrete Floor.* **A. R. Lord.** (Eng. News, 64. pp. 697–700, Dec. 22, 1910. Paper read before the Nat. Assoc. of Cement Users, New York, Dec. 18, 1910. Eng. Record, 62. pp. 788–788, Dec. 24, 1910.)—The floor, 9 in. thick, reinforced with rods, was supported on columns spaced 19 ft. centres, no cross-beams being used. It was designed for a load of 225 lbs. per sq. ft., and was loaded up to 850 lbs. per sq. ft., precautions being taken to prevent the arching of the load. Observations were taken on the deflection, the extension of the steel, and the compression of the concrete. In the outer panels and in those in which bulkheads were present the max. deflections were observed. The greatest elongation of the steel occurred over the columns, where it was two or three times as great as in the centre of the panels, although 75 per cent. more steel was employed over the columns. Readings on the concrete showed that a readjustment of the stresses took place when the load was left on for some time, the fibre stress being reduced. Cracks were observed first at bulkheads with loads from 260 to 800 lbs. per sq. ft. At higher loads circular cracks appeared over the columns and extended between adjacent supports. The positions of these cracks indicate the sections about which moments should be calculated. Other points brought out are, that the stresses are greatest over the columns, and that the presence of bulkheads increases the stress locally. C. A. M. S.

306. *Some Tests on Ligno-Concrete.* **C. A. M. Smith.** (Engineering, 90. pp. 890-891, Dec. 16, 1910.)—Contains results of tests on ligno-concrete, which is the invention of G. O. Case, and consists of the reinforcement of concrete by means of wood. It is not suggested that ligno-concrete should entirely replace ferro-concrete, but that it should be specially used to replace ordinary bulk-wood constructions such as piles, posts, beams, foot-bridges, &c. The method consists of first making a fixed wood framework and then filling in the space between and around with concrete, the whole framework being entirely covered up. The wood may be creosoted to increase its durability. The experiments were made on slabs 4½ × 4½ × 55 in., the reinforcements consisting of four ¾-in. square timber bars 2¼ in. from centre to centre and 52 in. long. Six bands 3 in. from each end and 9 in. apart of iron ½ × ⅛ in. were placed round and fastened to the timber rods by 3 screws. The concrete used was composed of 1 part granite chips, 2 parts fine sea sand and ½ part English Portland cement (B.E.S.C. specification). The span was 42 in. and the beams were loaded in the centre; the following results were obtained :—

Description of Beam.		Initial Cracking Load in Lbs.	Max. Load in Lbs.
Teak reinforcement	....	1400	2500
Deal „	....	—	2250
Oak „	....	1400	2240
Ash „	....	1000	1800
Mahogany „	....	1200	1595
Plain concrete	....	—	425

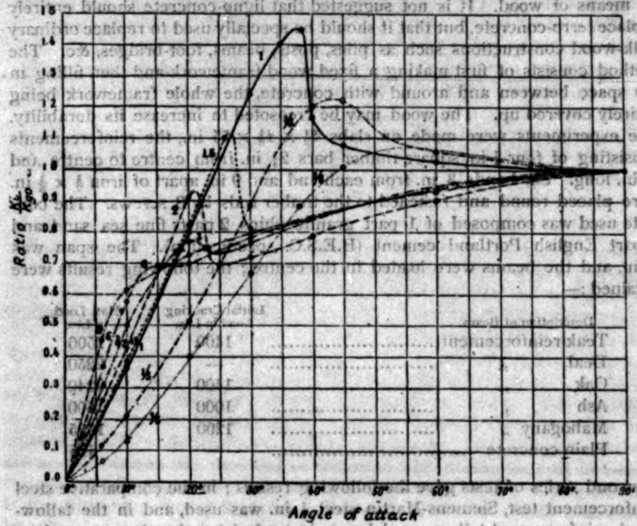
A second series of tests gave the following results; in the comparative steel reinforcement test, Siemens-Martin steel ½ in. was used, and in the tallow-wood reinforcement tallow-wood bands instead of iron bands were used :—

Description of Beam.		Age of Beam Days.	Initial Cracking Load in Lbs.	Max. Load, Lbs.
¾-in. Jarrah-wood reinforcement	...	10	850	3300
¾-in. tallow-wood „	......	10	1050	3150
½-in. steel „	......	14	900	1500
Plain concrete	....	10	—	650

Some account of cost is given, and the question of the durability of the material is discussed. It is pointed out that the above are only preliminary tests and an extensive series of researches is being commenced. C. O. B.

307. *Molecular Dimensions from Radiometer.* **P. Debye.** (Phys. Zeitschr. 11. pp. 1115-1121, Dec. 1, 1910.)—The author develops to a first and second approximation formulæ for the calculation of molecular dimensions from observations on radiometer workings with various rarefied gases. In this way the diams. of the molecules for hydrogen and oxygen are found to be $2{\cdot}9 \times 10^{-8}$ cm. and $3{\cdot}9 \times 10^{-8}$ cm. respectively. It is pointed out that by van der Waals' law and the thermal conductivity, viscosity, and diffusion, the above diams. are calculated to be respectively $2{\cdot}02 \times 10^{-8}$ cm. and $2{\cdot}70 \times 10^{-8}$ cm. The ratios by the author's method and by van der Waals' law are each about 1·44. [See Abstract No. 1180 (1910).] E. H. B.

308. *Resistance of Rectangular Plates Struck Obliquely by the Wind.* **G. Eiffel.** (Comptes Rendus, 151. pp. 979–981, Nov. 28, 1910.)—This article describes tests made in an artificial wind channel in order to determine the forces acting on rectangular plates impinged upon by air currents at various angles. The following diagram is given and attention is drawn to the maxima occurring on most of the curves, which phenomenon has not hitherto been pointed out. The ordinates represent the ratio K_i/K_{90} between the force per unit of surface of a plate making an angle *i* with the wind and the force acting on the same plate placed normally to the wind. The abscissæ represent the angles of incidence. Within the limits of the plate areas used the area of the surfaces appeared to have no influence on this ratio. A practical formula for angles between 0° and 8° or 10° is $K_i/K_{90} = i(3{\cdot}2 + n/2)/100$, where *n* is the ratio of length to width (between limits of 1 and 9), and *i* the angle of attack. The values of *n* are given in the Fig. at the side of each curve. C. A. B.



309. *Planck's Radiation Theory and Non-Newtonian Mechanics.* **J. H. Jeans.** (Phil. Mag. 20. pp. 948–954, Dec., 1910.)—Planck's conception of an indivisible atom of energy is to many unthinkable, as it involves a discontinuity of motion. Larmor has suggested a possibility of expression in terms of continuous motion [see Abstracts Nos. 704 and 1619 (1910)], but has not shown whether the suggestion would lead to a solution. The author, therefore, propounds and investigates the question, "Can any system of physical laws expressible in terms of continuous motion (or of mathematical laws expressible in terms of differential equations) be constructed such that a system of matter and æther tends to a final state in which Planck's law is obeyed ?" The answer obtained is that it is impossible. The investigation proceeds on the assumption, as law of causation, that the state of the system at any instant is determined by its state at the previous instant, and that it can be specified in terms of certain definite quantities as co-ordinates. The state at any instant can then be represented as a point in a generalised space and, from the primary assumption, there will be one only trajectory through each point, and the velocity at any part of the trajectory will be independent of the time. Assuming, as usual, that the collection of such points may be regarded as a continuous fluid, this fluid will move along fixed stream lines, and the velocity at any point will be constant. The initial distribution, being arbitrary, can be taken so that the density at any point is constant, so that the motion will be steady, and will remain so after such compression, dilatation and distortion as will give uniform density throughout, so that if $P_1, P_2 \dots P_n$, are the co-ordinates in the distorted space, $\Sigma(\partial P_r/\partial P_r) = 0$. Since one set of P's is possible, and a homogeneous fluid can be strained in an infinite number of ways so as to remain homogeneous, there will always be an infinite number of P sets possible. Then the application of the probability calculus on the basis of a random selection in which equal volumes have an equal chance of selection is shown to lead at once to Boltzmann's relation between entropy and probability. If part of the system be supposed a perfect gas, its co-ordinates may be assumed to be its Lagrangian co-ordinates and momenta, and its energy E_1 will be of the form $E_1 = \Sigma a_1 P_1^2$, containing, say, *m* terms. It is then shown that the second law of thermodynamics holds for the system, and that it is therefore more general than any system of dynamical laws. Moreover, assuming that any other part of the energy E_2 can be expressed in a similar form with *n* terms, it follows that $E_2 = \frac{1}{2}nRT$, and further, that if E_2 is any homogeneous function of the co-ordinates, and necessarily positive, the average energy of any *m* co-ordinates is proportional to *m* and to T, which is the equipartition of energy theorem. This also is therefore more general than any system of dynamical laws. Now experimental knowledge of wave-motion seems to place it beyond question that the energies of different frequencies must be represented by different sets of co-ordinates, and that each energy must necessarily be positive. This granted, the necessity for equipartition of energy between the different waves follows, and in a state of max. entropy the total radiant energy must always be proportional to the temperature, which establishes the author's contention. He then examines in detail the form assumed by the general argument when applied to the special problem under discussion, in which the system may be taken as a volume of ether in which a very small amount of matter is embedded, the function of the matter being solely to make possible the transfer of energy in the ether between vibrations of different wave-lengths. It is then shown that, however far removed the general equations of matter and ether may be from the standard form, yet when the matter is made to diminish indefinitely in amount, we may suppose, without any loss of generality, that the equations of wave-motion are of the standard form, and that the co-ordinates are the Lagrangian co-ordinates and momenta. Equipartition of energy follows as a direct consequence. The legitimacy of the assumption, in the general argument, that the whole of the generalised space was filled with fluid is finally examined, for the fluid must be excluded from any parts which represent physically impossible configurations, and if these parts are of sufficient extent, the exclusion may affect the final result. The author therefore considers the possibility of any arrangement of fluid which could change the law of equipartition into the widely different law of Planck. It is found that this would involve, not merely the existence of vibrators capable of holding only definite multiples of a fixed unit of energy, but an atomic constitution of the etheric energy itself, coupled with the physical impossibility of dividing these atoms. Moreover, Planck's theory necessarily supposes the unit of energy to be so great that the chance of a wave-length of moderate length having any energy at all is extremely small, one in 140 for wave-length $\lambda_{max.}$, and about one in 20,000 for waves of half this length. Further, if this theory were to be accepted at all, should it not be expected to account for the failure of certain other degrees of freedom, such as internal vibrations and rotations of atoms, to receive the share of energy allotted to them by the equipartition theorem? For a degree of freedom having one-thousandth of its equipartition energy, only one degree in 9100 would possess any energy, and the rough estimate from the specific heat, in the case, say, of the rotation of the atoms of mercury vapour, would lead to somewhat startling results. G. W. DE T.

310. *Transmission of Time Signals by Telephony and Radiotelegraphy.* **Claude, Ferrié, and Driencourt.** (Comptes Rendus, 151. pp. 985-988, Nov. 21, 1910.)—The system of transmission of time signals for longitude and other purposes has been much facilitated by the employment of telephony and wireless telegraphy. [See Abstract No. 641 (1910).] The present note gives results of some trials between Paris and Brest, using the military station on the Eiffel Tower. The difference between the two modes of comparison appears to be less than 0·01 sec., so that the radiotelegraphic method should be of great service in determining the longitude of out-of-the-way stations. C. P. B.

311. *Bending of the Supports of Pendulums used in Gravimetric Determinations.* II. **G. Abetti** and **C. Cappello.** (Accad. Lincei, Atti, 19. pp. 272-278, Sept. 18, 1910.)—As has been seen, it is advisable in gravimetric measures to employ a direct method of obtaining the correction σ to be applied to the times of oscillation of the pendulums to reduce them to what they would be if their supports were perfectly rigid [see Abstract No. 1888 (1910)]. The method used by Nagaoka, Shinjō, and Otani is described, and also that of Defforges. The sudden shifts of the supports are best observed by means of an interferometer. A modified arrangement differing slightly from that of Defforges, but essentially similar to that used by Michelson, has advantages, which are pointed out, and a description of the instrument and its theory follows. For the "quadripendulum" Sterneck-Stückrath, as well as for that of the Italian Central Meteorological Office, a different arrangement of the plate turning round the bronze covering has advantages. Another method, based on the use of quartz thread and similar to that proposed by Threlfall and Pollock but differing slightly in details, is also suggested, and a figure is given of the proposed apparatus. From the max. amplitude of these oscillations the momentary bendings of the support may be deduced. The unifilar system may be replaced by a bifilar one, regulating the distance of the two threads from one another. The method of Nagaoka may be made much more sensitive by the employment of two mirrors instead of one, and observing the deviation of the interference bands to which the two mirrors give rise. In the execution of gravimetric measures in volcanic regions, especially in those around Vesuvius where the constitution of the soil varies greatly from place to place, it is absolutely necessary to study these bendings, since they in their turn are variable from one station to another, and also it is advisable to make observations as far as possible at the same temperature, to avoid the error arising from an imperfect knowledge of the coefficients of expansion. By selecting whichever method is most suitable for the particular case, and by systematic observations made with the above-mentioned precautions, it will be possible to reduce the anomalies in the values of g obtained in these regions, and to throw important light on the constitution of Vesuvius and its whole volcanic region. F. W. H.

312. *Gravity Determinations at Sea.* **L. A. Bauer.** (Amer. Journ. Sci. 31. pp. 1–18, Jan., 1911. Paper read before the Philosophical Soc., Washington, Nov. 5, 1910.)—The author discusses the methods of determining at sea the variations in gravity. The most accurate method yet devised depends on boiling-point determinations, and it has been very fully worked out by Helmert and Hecker. The method consists in deducing by means of tables the atmospheric pressure A from the boiling-point of pure water, and comparing the result with the atmospheric pressure B simultaneously observed with a mercurial barometer, and reduced to standard temperature, to sea-level, and to normal gravity for latitude 45°. Then (A–B) is the gravity anomaly, and Δg is very approximately $980/760 . (A-B)$ c.g.s. units. The author draws attention to the chief errors in these determinations, viz., those due to (1) speed of the vessel in longitude, (2) rolling or yawing, (3) vibration caused by machinery, (4) pitching and accompanying vertical motions, (5) purely instrumental errors. He explains the method used by Hecker to allow for these, and points out that Hecker's methods of correction assume that during a cruise the local gravity anomalies, *i.e.*, the Δg's, partake of the nature of accidental errors, and that the average gravity anomaly of a whole cruise is zero. The author proposes undertaking a series of gravity determinations on board the *Carnegie*, and gives an account of some improvements which he intends introducing in the method of observation and of reducing the results. These may be grouped as follows: (1) simpler methods of observing, (2) a new manner of mounting and constructing the barometers to reduce the errors due to motion of the vessel and to enable these errors to be accurately determined, (3) the combination of shore and harbour experiments with those made at sea. In conclusion the author emphasises the importance of improved vapour-pressure tables for water between 99 and 101° C., if gravity determinations are to be made with a probable error of less than 1 in 50,000. A. D. R.

313. *Gravity Determinations.* **O. Hecker.** (Veröffentl. d. Zentralbureau d. intern. Erdmessg. No. 20, Berlin, 1910. Zeitschr. Instrumentenk. 31. pp. 24–28, Jan., 1911. Abstract.)—This paper falls into three parts. The first deals with pendulum observations made at Odessa, Tiflis, and Bukarest; the second describes gravity determinations carried out on the Black Sea by the aid of boiling-point thermometers and mercury barometers; while the third is a detailed discussion of previously published results for the Atlantic, Indian, and Pacific Oceans. In Part II. are given particulars of improved apparatus for use in oceanic surveys. After an account of the observed differences in readings of the various thermometers employed and their origin, the author describes a new type of marine mercury barometer provided with photographic registration and little affected by vertical motion of the ship. Formulæ are derived to correct the observed readings of the barometers for the speed of the vessel in longitude. The investigations

carried out in the deep Black Sea have shown that the values of gravity there are practically normal and agree well with Helmert's formula. The relatively low density of the water of the Black Sea is compensated for by the high density of the material below the bed of the sea, the arrangement fulfilling the conditions for isostasy. A. D. R.

314. *A. Berson's Aerological Expedition to East Africa,* 1908. **R. Süring.** (Meteorolog. Zeitschr. 27. pp. 536–542, Dec., 1910.)—Berson and Elias were sent to East Africa by the Prussian Aeronautical Observatory, and have studied the monsoons with the aid of registering rubber balloons and kites, sent up from a ship on the Victoria Nyanza, 1140 m. above sea-level, and from the coastal districts of Zanzibar and Mozambique. Over the great lake the temperature decrease with height was very marked and fairly continuous; the very low minimum of — 84·3° C. was observed at 19,800 m.; the gradient ranged roughly between 0·6 and 0·7° per 100 m. up to 18,000 m. with maxima of 0·74 and 0·75°/100 m. near 8000 and 11,000 m., and minima of 0·58° at 6000 m., and finally of 0·16° per 100 m. and less above 17,000 m. The wind intensity increased with height from 8·6 m./sec. to 14·9 m./sec., but decreased about the 8000-m. level, up to which the humidity increased. Temperature inversions were not frequent; there was one between 15,000 and 17,000 m. The air circulation above the lake in July to Sept. is complex. In the first few hundred m. local winds, especially sea winds and vertical currents, are prominent; then follow up to 3500 m. (above sea-level, as in the other statements) feeble monsoons influenced by diurnal variations; higher up an anti-monsoon of seasonal character extending up to 6500 or 8800 m., with a northerly component; above that easterly winds, and in the highest strata (above 12,000 m.) sometimes westerly winds. This peculiar westerly current has since been observed also by van Bemmelen and Braak, to whom reference is made, in Batavia. Below 4000 m. the circulation is further complicated by aspiration currents up to the cumulus (thunderstorms) which, on the east coast of the lake, draw from the land over the lake in the afternoon. On the ocean coast the land and sea winds were also confined to the first 300 or 500 m. H. B.

315. *Humidity Observations in California.* **J. Hann.** (Meteorolog. Zeitschr. 27. pp. 522–524, Nov., 1910.)—The author describes the expedition from Lick Observatory to the summit of Mt. Whitney in Aug., 1909, to determine the amount of water-vapour present in the atmosphere of Mars. The results depended on the degree of exactness with which the humidity of the earth's atmosphere could be determined; then by comparative spectra of the Moon and Mars at about equal altitudes, the intensity of the "*a*" water-vapour red band was measured. It was concluded that little evidence was shown of the presence of more water-vapour on Mars than on the Moon. C. P. B.

316. *Variation in the Intensity of Moonlight during an Eclipse.* **J. Elster** and **H. Geitel.** (Phys. Zeitschr. 11. pp. 1212–1214, Dec. 15, 1910.)—Measurements were made during the lunar eclipse of 1910, Nov. 16–17, with a photoelectric potassium cell [see Abstract No. 958 (1910)]. Calculation gave 10.46 and 11.44 p.m. as the times of first contact with the penumbra and umbra respectively. Clouds interrupted observations until 11.8, and at 11.15 the apparatus indicated a falling-off in the light intensity due to the eclipse although no change was perceptible to the eye until 11.24. The rate of diminution in the light reached a maximum about 11.50, and the light was still decreasing at 12.25 when clouds again interrupted observations. A curve of light intensity is given for the period from 10.34 to 12.35. A. D. R.

317. *Effect of Halley's Comet on Earth's Atmosphere.* **J. Aitken.** (Roy. Soc. Edinburgh, Proc. 30. pp. 529–550, 1909–1910.)—The author examined a particular section of atmosphere in the Scottish N.W. Highlands during the period of conjunction with the comet, particularly with regard to the number of dust particles present per unit volume before and during the passage of the comet. Observations were started on May 18, 1910, and continued until the end of the month. Comparisons were made of the number of dust particles found with varying directions of wind. The only times when any abnormal features were noticed were May 24, 25, when the number of particles rose to 5500 and 8500 per cm.³ respectively. This may be attributed either to the presence of the comet or to varying weather conditions, there being an irregular, feeble anticyclone over the district, with no general circulation. Observations of atmospheric electricity were also made with a common leaf electroscope and a Glew radium collector. After 10 p.m. on May 18 a series of decided negative electrifications were noted, but next morning the usual positive discharges had again become effective. Shortly after 7 a.m. a series of alternating electrifications were observed, after which there only remained the steady positive charge. No abnormality could be detected in the character of the sunset colours throughout the period of the comet's passage. The general conclusion is that no phenomena could be attributed with certainty to the proximity of the comet to the earth. C. P. B.

318. *Antarctic Tides.* **Godfroy.** (Comptes Rendus, 151. pp. 1405–1407, Dec. 27, 1910.)—During the French south polar expedition a series of observations were made of the tidal wave at Port Circoncision (Petermann Island) in lat. 65° 10′ S. and long. 66° 34′ E. An analysis shows that considerable preponderance of the diurnal wave which is usual at such a latitude. Among the waves of long period, the observations (which were limited to 225 days) have only enabled the lunar waves to be isolated. But on examination of the curve showing the daily mean sea-level, the occurrence of an important perturbation of long period is clearly seen. It is found that this is the resultant of two component waves of 25 cm. amplitude, and of periods of one and of three weeks respectively. The latter wave has not previously been detected, and is probably due to some meteorological cause, though attempts to connect it with barometric or wind changes have proved unsuccessful. A correspondence has, however, been found between the daily mean sea-level and the barometric pressure, although the variations are not periodic in character. The paper concludes with a discussion of the velocity of the tidal waves in the region between South America and the Antarctic Continent. A. D. R.

319. *Registration of Artificial Earthquakes.* **L. Fabry.** (Comptes Rendus, 152. pp. 296–298, Jan. 30, 1911.)—The seismograph at Marseilles Observatory has recorded several disturbances originating in a mining district lying some 12 miles to the north-east. The shocks are perceptible near their source and are due to the snapping of rock strata which, by the cutting out of galleries in the coal-mines, have been strained beyond the elastic limit. The seismographic records show a small and rapid vibration, the period being less than 1 sec., and the maximum amplitude corresponding to a displacement of the ground of only 0·01 mm. This is an interesting result as showing the pos-

sibility of studying over a distance of several miles seismic disturbances which at their centre sensibly agitated buildings and which are due to known causes. A. D. R.

320. *Effective Diameters of Stars.* **C. Nordmann.** (Comptes Rendus, 152. pp. 73–74, Jan. 9, 1911.)—Various attempts have been made to calculate diams. of stars whose parallaxes are fairly well determined, but they all involve certain assumptions which apparently lead to difficulties. In the present note a new term is introduced, the *effective intrinsic brightness,* and by means of an empirical formula this function is collated with the results of observations made with the author's stellar photometer. He thus gets a series of diams. for 10 of the chief stars. In general this table shows that the stars whose effective temperature is greater than the sun have small diams., while those of similar or less temperature to the sun are of greater diams. Thus Aldebaran (α Tauri) with an effective temperature of 3500° C., is computed to have an effective diam. 18·5 times that of the sun, and β Andromedæ is very similar. On the other hand, Sirius and Procyon, with effective temperatures of 12,200° and 6810°, are given diams. of 1·18 and 1·35 times that of the sun respectively. C. P. B.

321. *Photographic Stellar Photometry.* **E. C. Pickering.** (Harvard College Observatory Circular, No. 160. Nature, 85. p. 181, Dec. 8, 1910. Abstract.)—In the Harvard system a standard sequence of polar stars is photographed on the plate bearing the stars under examination, and the investigation has been extended down to stars of the twentieth magnitude. For most of the fainter stars this method is not so suitable as another which has been devised, involving the attachment of a small circular prism of small angle at the centre of the objective. This deviates a small predetermined proportion of the incident light to another part of the plate, thus providing an automatic comparison for each star image. **E. Hertzsprung.** (Astronom. Nachr. No. 4452. Nature, 85. p. 181, Dec. 8, 1910. Abstract.)—Hertzsprung proposes to compare the density of the direct star image with that produced when a grating is placed over the objective. C. P. B.

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322. *Anemometer for Measurement of the Vertical Component of the Wind's Velocity.* **P. P. Ewald.** (Phys. Zeitschr. 11. pp. 1214–1216, Dec. 15, 1910.)—The author gives the mathematical theory of Angot's vertical anemometer and suggests a modification of the apparatus to minimise certain imperfections. A. D. R.

323. *Phenomena of Propulsion.* **J. B. Henderson.** (Inst. Naval Architects, Trans. 52. pp. 58–70 ; Discussion and Correspondence, pp. 82–106, 1910. Engineering, 89. pp. 394–396, March 25, 1910. Abstract.)

324. *Model Screw Propeller Results: A Comparison.* **T. B. Abell.** (Inst. Naval Architects, Trans. 52. pp. 71–81 ; Discussion and Correspondence, pp. 82–106, 1910. Engineering, 89. pp. 492–496, April 15, 1910.)

325. *The Dynamics of a Golf Ball.* **J. J. Thomson.** (Nature, 85. pp. 251–257, Dec. 22, 1910. Discourse delivered at the Royal Inst., March 18, 1910.)

326. *Formulæ and Tables for Converting Right Ascension and Declination of a Star into Standard Co-ordinates.* **A. A. Rambaut.** (Roy. Astronom. Soc., M. N. 70. pp. 655–672, 1910.)

LIGHT.

327. *A Stereoscopic Illusion.* **F. G. Baily.** (Roy. Soc. Edinburgh, Proc. 30. pp. 551–554, 1909–1910.)—When a thin rod was held vertically in front of the eyes, and another more distant rod was looked at, so that the second rod was seen between the two images of the first, the apparent position of the second rod was distinctly nearer than its real position. The first rod was placed 6 ft. away from the observer, and the second at a distance which varied from 20 to 110 ft. The displacement measured was found to disappear at 20 ft., and increased in a linear manner with the distance of the second rod, being 14½ ft. for a distance of 110 ft. G. E. A.

328. *Measuring Apparent Diameter of the Pupil of the Eye, in very Feeble Light.* **T. H. Blakesley.** (Phil. Mag. 20. pp. 966–969, Dec., 1910.)—The advantage obtained by the magnifying power of a telescope or microscope may be seriously diminished if the orifice of the eyepiece is so small that the emergent beam does not fill the pupil. If the object is very faint or small, the field is necessarily dark, and the pupil wide open. The author's apparatus for measuring the pupil under such conditions consists of what is virtually one tube of a common opera-glass, with the eyepiece removed Into the sliding tube is inserted another longer tube, and this is pushed home until stopped by an offset at the end of the outer tube. With the apparatus at its longest, the distance from the open end to the object-glass may be measured, and also the exposed portion of the outer sliding tube. In any other position the defect in the latter is equal to that in the former. In contact with the object-glass on its near side, is inserted a screen of black paper. Two small pinholes PP′ are made in one diam. of the screen, and equidistant from the centre. The instrument is directed upon a distant light on a dark night. A pair of fine beams will then pass through the pinholes PP′, and converge to the focus F. These will both be visible to an eye in the optic axis, if the interval between the beams at the eye is less than the diam. of the pupil. Let E be the position of the eye in which this is just possible, E lying between F and the objective. The inner tube is withdrawn after E is found, and a second, longer, tube is inserted, by help of which the second position E′, on the far side of F, is found, where the distance between the beams of light is again equal to the diam. of the pupil. The eye being always held close to the end of the tube, the distance EE′ may be taken as equal to the difference between the distances from the lens of the open ends of the two tubes. If L and l denote these distances, D the interval between the pinholes, and f the focal distance, then the diam. d of the apparent pupil is given by the equation $d = D(L - l)/2f$. In the author's own case, the value of d is found to vary from 6·74 to 7·20 mm., and he regards the value ⅓ in. (8·47 mm.), sometimes quoted in text-books, as abnormal. A. E.

329. *Dispersion of Metals in the Infra-red.* **L. R. Ingersoll.** (Astrophys. Journ. 32. pp. 265–290, Nov., 1910.)—A study of the refraction and absorption constants of steel, Co, Ni, Ag, Cu, and Si over the range of spectrum from $\lambda = 0{\cdot}65\,\mu$ to $2{\cdot}25\,\mu$. The elliptically polarised beam reflected from the metallic mirror was reduced to two rectangular components by passage through a double-image prism. On passage through the spectrometer, two spectra were formed which were examined by means of a special bolometer. From the results obtained, the first five metals show an increase of refractive index with increasing wave-length, but silicon is exceptional in this respect. The absorption index decreases in some cases and increases in others, but in general does not show nearly as much change beyond wave-length 1 μ as for shorter waves. The extinction coefficient shows a gradual increase with the wave-length. The reflecting powers computed from the constants are in good agreement with the observed values of Hagen and Rubens, especially for the longer wave-lengths. Also, on certain assumptions, Voigt's equation connecting the optical constants and the Kerr rotation is fulfilled for the longer waves though not for the shorter, and these facts go to bear out the author's contention that, once outside the visible spectrum, we may expect a much better agreement between theory and experiment in the case of the optical properties of metals. [See also Abstract No. 225 (1910).] G. E. A.

330. *Studies on the Firefly.* **H. E. Ives.** (Phys. Rev. 31. pp. 637–651, Dec., 1910.)—Coblentz in conjunction with the author has described an investigation of the visible radiation from one variety of firefly (*Pholinus pyralis*) [see Abstract No. 312 (1910)]. The chief difference between that investigation and preceding ones lies in the application of photography with colour-sensitive plates. The object of this paper is to discuss more fully the grounds for believing that the firefly's visible radiation is its total radiation. Experiments in the infra-red and ultra-violet regions of the spectrum are described. The region from 0·2 μ to 1·5 μ was explored. The only radiation was in a narrow band at 0·57 μ as previously found. The abdominal skin of the insect is proved to be transparent as far as 3 μ. The light appears to be under the control of the insect, and has none of the properties of true phosphorescence, such as dependence on previous exposure to light or extinction by long waves. The light is due to some biochemical process which there is no reason to suppose cannot be artificially produced by man. A. R.

331. *The Dufay Dioptichrome Plate.* **A. C. Braham.** (Photographic Journ. 50. pp. 350–352; Discussion, pp. 352–354, Nov., 1910.)—The principle of construction of this screen plate is as follows: If on a surface capable of absorption, that is, a glass plate coated with gelatine, part of the surface be coated with a fatty body, and the plate then be introduced into an aqueous solution of a dye, it will be evident that the dye will be absorbed in those parts not covered with the fatty body. Then follows the process which enables successive rulings and dyeings to take place without overlapping. The whole surface is varnished with a varnish fulfilling two conditions: (*a*) its solvent must not dissolve the greasy material used, and (*b*) its resin or gum must be insoluble in a solvent of the greasy material. Such a varnish adheres strongly to the gelatine at the points where the colour is absorbed, but where it is in contact with the greasy material it covers it without becoming incorporated with it. A preponderance of red occurs in some plates which have been under-exposed. A green safe-lamp is used when developing the plates. During the *discussion*, **C. P. Butler** pointed out that in the photographs of the spectrum when using these plates there is a large dark band between the green and the blue which would prevent their use in spectrum photography. According to E. Marriage, the length of exposure required appears to be about the same as that for the autochrome plates. A. E. G.

832. *Influence of Size of Grain upon the Latent and Visible Photochemical Decomposition of Silver Haloids.* **A. P. H. Trivelli.** (Zeitschr. wiss. Phot. 9. pp. 168–172, Dec., 1910.)—The problem considered is: Why does the insensitive silver chloride printing-out paper decompose much quicker in daylight than the more sensitive gelatino-bromide silver plates? The silver haloid grains in the P.O.P. are ultra-microscopic, while those in the gelatino-bromide plates have a diam. of 5–9 μ. It is shown that one would expect the emulsion containing the fine grains to ultimately undergo a greater degree of blackening than the coarse-grained emulsion. Hence when the blackenings are plotted as ordinates and the exposures as abscissæ, and the curve ultimately becomes parallel to the axis of exposure, that representing the fine-grained emulsion will lie above that representing the coarse-grained emulsion. The first part of the curve in each case is almost a straight line, making an acute angle with the exposure axis. This angle for the coarse-grained emulsion is much smaller than for the fine-grained, and it is shown that these lines may therefore intersect at a point beneath a line drawn parallel to the exposure axis to represent the limit of the latent process. Hence it can be seen that in some measure the size of the grain may be looked upon as accountable for the peculiar behaviour of the gelatino-bromide plates as compared with P.O.P. A. E. G.

833. *Report of Progress on Flame Standards.* **E. B. Rosa** and **E. C. Crittenden.** (Amer. Illum. Engin. Soc., Trans. 5. pp. 758–778; Discussion, pp. 778–787, Nov., 1910.)—An account of the merits and defects of the Hefner amyl acetate lamp and the Harcourt 10-c.p. pentane lamp. With regard to the Hefner lamp, eight are in use at the Bureau of Standards, and the results obtained with these leads to the conclusion that the specifications are not sufficiently precise, and also that in some lamps there are slight departures from the specifications. With regard to the two styles of sight, the Krüss alone is recommended. Many determinations of the humidity correction have been made, and the result is in close agreement with that of Liebenthal, who first determined the correction at the Reichsanstalt. As a standard for comparison the authors used a carbon filament lamp operated at about 9 watts per candle, which gives a colour match with the Hefner. The mean results obtained with six lamps at 40 mm. flame height is 0·896 int. candle for the first three, and 0·908 int. candle for the second three. At 45 mm. flame height the respective means are 0·992 and 1·000. With regard to the pentane lamp, the authors find a greater difference among different pentane lamps than among different Hefner lamps. It is well known that the lamp increases in c.p. for some time after lighting up, but hitherto no careful measurements appear to have been made to show when the light reaches its stationary value. Four curves illustrating the variation are given in the paper. The highest c.p. obtained from any pentane lamp tested at the Bureau is 9·9, whereas the lamp at the National Physical Laboratory is 10 c.p. The question of the humidity correction is very fully discussed, and the barometric pressure correction is stated to be about 0·6 per cent. for a change of 1 cm. in the pressure. The authors conclude that much remains to be done on the pentane lamp to make it a thoroughly satisfactory flame standard, but the results so far obtained are encouraging. F. E. S.

834. *Determination of Relative Wave-lengths.* **I. G. Priest.** (Bureau of Standards, Bull. 6. pp. 578–606, Nov., 1910.)—By slight modifications of the Fabry and Perot procedure of employing interference fringes the author claims to have instituted a more sensitive experimental routine, with consequent improvement in the accuracy of determination of secondary standard wave-lengths. The method is characterised by three chief features: (1) The use of reflection fringes converged by a very short focus lens (20 mm.), thus enabling the disappearances of the bright central spot of the interference rings to be accurately counted; (2) the use of the double increment in the distance between the two mirrors instead of the double distance as the difference of path; (3) the use of the method of flexure for the measurement of the fractional part of the order of interference, a ratio of 1 : 7500 being obtained by means of a lever and springs. Details of the apparatus constructed on these lines are given, with an example of a determination and discussion of the probable error involved. In conclusion, a comparison is made between this proposed method and the more common one involving the measurement of the diams. of the interference rings. C. P. B.

335. *Flame-spectra and the Vacuum Bolometer.* **E. Buchwald.** (Ann. d. Physik, 33. 5. pp. 928–950, Nov. 10, 1910. Extract from Dissertation, Breslau.)—The theory of the vacuum bolometer has previously been given by Warburg, Leithäuser, and Johansen, who also tested experimentally the formulæ obtained [Abstract No. 2099 (1907)]. The present author has investigated further the properties of the vacuum bolometer, and employed it in a research on flame spectra. The bolometer used had three strips, of breadth (I) 0·5 mm., (II) 0·2 mm., and (III) 0·15 mm. respectively. I and III were 12 mm. long, and II had a length of 16 mm. The resistances were 4·16, 10·27, and 10·9 ohms. Dewar's liquid-air method of obtaining high vacua was employed. Using a definite wave-length, the sensitiveness of the different strips was found for various current strengths and different small pressures. With strip III the sensitiveness at atmospheric pressure is almost proportional to the current (up to 0·09 amp.); at 1 mm. pressure there is an appreciable curvature of the line; at 0·3 mm. pressure the sensitiveness curve shows a max. value for a current of about 0·065 amp., and as the pressure is further reduced the max. sensitiveness increases considerably, while at the same time smaller and smaller currents are required to give this maximum. With the broader strip II similar results were obtained, though in most cases the max. sensitiveness lies beyond 0·1 amp., which was the greatest current that could be safely used. With strip I the maximum was not reached for any vacuum. These results are discussed, and satisfactory explanations given. The latter part of the paper deals with (i) a determination of the temperatures of the carburetted hydrogen flame and the Bunsen flame; (ii) the absorbing power of the Bunsen flame for the CO_2-band 4·4 μ; (iii) demonstration of black CO_2-radiation of wave-length 4·85 μ; (iv) comparison with absolute black body; (v) structure of the CO_2-band 4·4 μ; (vi) hydrogen- and CO_2-bands in other sources of radiation; (vii) employment of CO_2-radiation for determination of spark temperature. A brief abstract of the results cannot be given. A. W.

336. *Emission and Absorption of Luminous Gases under Direct Currents of High Density.* **W. Jungjohann.** (Zeitschr. wiss. Phot. 9. pp. 84–103, Oct.; 104–129, Nov., and pp. 141–166, Dec., 1910.)—An account of intensity measurements in the spectra of nitrogen, hydrogen, CO, and oxygen. Wehnelt tubes of various forms and with different-sized capillaries were employed, with and without incandescent kathodes; the current density sometimes reached 60 amps./$cm.^2$. A special tube was used which is intermediate between the Wehnelt tube and the high-voltage tube. Its kathode was provided with a small piece of Pt which had previously been dipped in an aqueous solution of $CaNO_3 + BaNO_3$ and heated in a Bunsen flame. The retention by the Pt of a thin coating of the oxides enables the tube to act automatically with a p.d. of 800 volts, or at most requires the presence of a rubbed ebonite rod to start it. The tube is made of quartz, the gas within is at a pressure between 0·5 and 10 mm., and when currents of 1·5 amp. were employed the spectra of the capillary contained, as a rule, no metal lines. The intensity measurements were made by means of a Vierordt spectrophotometer, and many tables of figures and curves are given, the results obtained being somewhat as follows: *Nitrogen.*—The intensity in the positive bands of the first group is proportional to the current density; in the second group the intensity increases faster than the current density or the energy consumption. The band spectrum was not transformed into a line spectrum; absorption was not observed in luminous nitrogen; there was no temperature effect. *Hydrogen.*—The lines of the first sub-series vary with pressure. In two of the lines investigated the absorption increased in proportion with the pressure and reached 100 per cent. with a layer 6 cm. thick. No satisfactory relation could be found to exist between the changes of intensity and those of current density and energy consumption. With change of current density and of pressure the energy maximum is displaced. This displacement, however, does not correspond with that of the energy maximum in the spectrum of the black body with rise of temperature. *Carbon Monoxide.*—The intensity of the red and green bands increases in a nearly linear manner with the current density and energy consumption; with the blue bands the increase is more rapid. With stronger currents (higher temperatures) the energy maximum is displaced towards the short-wave region. In conclusion, it is remarked that different parts of the spectrum follow different laws. Further, neither current strength, energy consumption, nor temperature can be treated as the independent variable from the variation of which the change in the energy spectrum of a gas might be deduced. In many cases the change of the spectrum under increased expenditure of energy follows the behaviour of a temperature radiation. G. E. A.

337. *Colour and Absorption Spectra of some Sulphur Compounds.* **J. E. Purvis, H. O. Jones, and H. S. Tasker.** (Chem. Soc., Journ. 97. pp. 2287–2297, Nov., 1910.)—An examination of the absorption spectra of sulphur compounds shows that: the replacement of oxygen by sulphur causes a marked increase in the absorptive power of the compound, and often results in the production of colour. An absorption band also appears in some cases. In certain aromatic compounds, such as phenol and benzyl alcohol, the replacement of oxygen by sulphur results in obliterating absorption bands. L. H. W.

338. *Absorption Spectrum of Bromine at High Temperatures.* **E. J. Evans.** (Astrophys. Journ. 32. pp. 291–299, Nov., 1910.)—The apparatus is very similar to that employed in the investigation of iodine [see Abstract No. 60 (1911)]. The bromine vapour for the observations of absorption was heated in a quartz tube, placed inside an electric furnace, and connected with a bulb into which the liquid bromine was introduced. The bulb was put in a beaker of alcohol, and low temperatures were obtained by dropping solid CO_2 into the liquid. The beaker itself was placed in a larger vessel and the space between them filled with the bad conductor called kieselguhr. Experiments were made both with constant pressure and constant mass of the vapour in the tube, and show fair agreement. The conclusions reached are: (1) The absorption spectrum of bromine disappears at high temperatures, and the temperature of disappearance is increased by increase of pressure. (2) The disappearance of the absorption lines is closely connected with the dissociation of the diatomic molecules, and can be explained on the hypothesis that the monatomic molecules produced by dissociation give no absorption spectrum within the limits λ5500 to λ6800. An experiment to determine the quantity of bromine detectable by its absorption spectrum indicated that $4{\cdot}7 \times 10^{-6}$ gm. of bromine vapour in the diatomic state could be detected at 880° C. A. E.

339. *Ultra-violet Absorption in Oxygen.* **H. v. Wartenberg.** (Phys. Zeitschr. 11. pp. 1168–1172, Dec. 8, 1910.)—The absorption in oxygen at high temperatures was measured by means of a photoelectric cell. The spectrum of a mercury lamp was passed through a heated tube which could be filled with oxygen or nitrogen, and measurements were taken from λ254 to 210 μμ. The absorption of ultra-violet by oxygen at 0° ends at about 186 μμ; the effect of heating the oxygen to 1800° C. extends the absorption band towards the red end of the spectrum to beyond 300 μμ. [See also Abstract No. 760 (1910).] G. E. A.

340. *Emission of Series- and Ground- or Fundamental Spectra in the Glow Discharge with Vapours of the Alkali Metals.* **G. Gehlhoff.** (Deutsch. Phys. Gesell., Verh. 12. 22. pp. 970–974, Nov. 30, 1910.)—The different parts of the glow discharge in the vapours of Na, K, Rb, and Cs exhibit different behaviour in respect to the emission of primary and secondary series and ground spectra. These vapours likewise differ in many respects from one another so far as their spectrum, as obtained in a discharge tube, is concerned. In the anodic glow the vapours of all the alkali metals show primary and secondary series. In the positive light column there are changes in the spectra observed with increasing atomic weight of the metals. Thus with Na only the primary series appears, while with Rb and Cs both primary and secondary series can be seen. Potassium lies midway between these, showing primary series, but only a very weak secondary series. With the negative glow in Na, on the contrary, we have primary and secondary series, and secondary series and ground spectra with the other three metals. The assumption is made that the atoms of the alkali metals give out the primary series by collisions with particles having relatively low velocity; that by collision with particles of greater velocity the secondary series are generated; while collisions with the most rapidly moving electrons are the cause of the ground spectrum. Experimental data appear to support this hypothesis. The alloy of Na and K is also examined, and various analogous spectroscopic appearances in other gases are likewise discussed. A. E. G.

341. *Resonance Spectra of Iodine Vapour.* **R. W. Wood.** (Phys. Zeitschr. 11. pp. 1195–1196, Dec. 15, 1910.)—The author's previous work has shown that the complicated spectra yielded by sodium vapour excited to fluorescence by white light can be resolved into several simple series of nearly equidistant lines (which he names resonance spectra), by using various monochromatic lights to excite the fluorescence. The fluorescence spectrum of iodine was found to resemble that of sodium. It has now been further discovered that the fluorescence spectrum of iodine can similarly be excited by monochromatic light-sources so as to give resonance spectra. So far only one source of light has been experimented with, viz., the mercury arc, the most active line of which is the green line 5460 Å.U. The iodine vapour is contained in very large vacuum tubes, 20 or 30 cm. diam., made from round flasks. The neck is drawn out in a blow flame, a few iodine crystals are inserted, and a very high vacuum produced in the flask. The neck is then melted shut. When an arc light is focussed upon the middle of the flask, by means of a powerful projection lens, the fluorescence is bright enough to be seen across the largest lecture-room. With condensed sunlight the intensity of the fluorescence in the green is nearly ¼ that of an Auer light. The colour of the fluorescence obtained with the mercury arc (Heraeus) is a ruddy yellow, quite different from the yellowish green obtained with white light. Examination with the spectroscope reveals, in place of the immense number of lines forming the characteristic bands of the iodine spectrum, a fine series of isolated lines at intervals of 65–70 Å.U. The wave-lengths have only been roughly measured as yet. The green mercury line at 546 $\mu\mu$, being the exciting line, always appears; and in addition the resonance spectrum contains two lines of shorter wave-length than the exciting line, two strong and two very weak lines between the green line and the double yellow line of mercury, and seven or eight lines in the red. Several mercury lines due to diffused light generally appear also. It seems likely that more results can be obtained with iodine vapour than sodium, since the work can be performed at ordinary temperatures with glass vessels. A. E.

342. *Doppler Spectrum of Hydrogen Canal-rays.* **E. Gehrcke and O. Reichenheim.** (Deutsch. Phys. Gesell., Verh. 13. 2. pp. 111–118, Jan. 30, 1911.)—In the first part of the paper earlier results and conclusions [see Abstracts Nos. 1428 (1910) and 153 (1911)] are discussed. In the second part some new experiments upon the Doppler-effect of the line H_β of hydrogen are described. From these it is apparent that the distribution of intensity in the Doppler spectrum with equal kathode-fall depends upon the magnitude of the kathode. With a kathode of 1·5 mm. diam. two sharp Doppler maxima for kathode-falls of about 600 to 1100 volts are obtained; these maxima have almost equal intensities between 700 and 800 volts; with diminishing pressure the sharpness of the Doppler lines decrease. This has also been observed by Paschen for kathodes of 4·5 cm. diam. These results are not in agreement with the assumption that the rays due to the hydrogen atoms and molecules receive their velocity through the same accelerating cause. In the earlier researches with larger kathodes and smaller pressures the relation between the wave-length differences for the two Doppler maxima was about $\sqrt{2}$; it is now found with higher pressures that this ratio is clearly greater than $\sqrt{2}$. Further experiments are needed before an explanation of this can be given. A. E. G.

343. *Mercury Series.* **L. Grebe.** (Phys. Zeitschr. 11. pp. 1121–1122, Dec. 1, 1910.)—Previous work on the laws of temperature radiation and the distribution of intensity in the spectrum of the mercury lamp in quartz is first dealt with [Abstracts Nos. 1607 (1906), 1182 and 1183 (1907), 1796 (1908), and 698 (1910)], and then tables and curves are given of the author's results for certain series lines of mercury. The apparatus used was the same as that employed by Pflüger [Abstract No. 1796 (1908)], and was furnished with rock-salt lenses. Each line was observed for two different energy consumptions of the lamp (500 watts and 290 watts), and in each series the galvanometer deflection increases more rapidly for increased wave-length with the larger consumption of energy. The series dealt with were the first, second, and third members of the first triplet series, and the first members of the second triplet series. A. W.

344. *Behaviour of the Mercury Line 5789·88 in the Magnetic Field.* **P. Gmelin.** (Phys. Zeitschr. 11. pp. 1193–1196, Dec. 15, 1910.)—The Zeeman-effect for the mercury line 5790·87 is peculiar in so far that the middle component of the Zeeman triplet, vibrating parallel to the lines of force, shows a shift towards the red proportional to the square of the strength of field. This line has a satellite, 5789·88, on the blue side, whose vibrations are closely related to its own by the laws of series. Since the peculiar behaviour of the principal line may be due to the neighbourhood of the satellite, observations of the satellite in the magnetic field were undertaken. A Rowland concave grating, radius of curvature 6·5, was employed, adjusted so that the line examined fell in the grating normal. A parallel beam of light was directed on the grating from a concave mirror. Special care had to be taken in preparing the Geissler tubes. Ocular qualitative examination gave the following results: (1) The satellite shifts markedly towards the violet as the strength of the field increases, the direction of shift remaining unaltered when the magnetic field is commuted. (2) It splits into a very symmetrical triplet whose outer components are considerably fainter than the middle line. (3) The component shifted towards the violet vibrates perpendicularly to the magnetic lines of force, that towards the red parallel to them. The middle line appears not to be polarised, since it does not vanish for any position of the analysing nicol. It always appears stronger than the unextinguished outer component, both in the direction of vibration parallel, and in that perpendicular, to the lines of force. In order to determine the strength of field and the changes of wave-length of the satellite, the distances of the middle line of the satellite from the outer components of the lines 5769 and 5790·9 were measured with a Zeiss comparator. From previous work the specific Zeeman separations for the latter lines were assumed to be 10·78 and 9·91 respectively, and the wave-length of the satellite to be 0·999 Å.U. less than that of the line 5790·9. The shift of the satellite was found to vary directly as H, the strength of field, not as H^2. Thus $d\lambda = H(-9{\cdot}25) \times 10^{-13}$. The specific Zeeman separation of the satellite was found to be $(4{\cdot}8) \times 10^{-5}$. In this phenomenon of the satellite triplet shifting bodily with its outer components, while the only middle component of the unsymmetrical triplet 5790·9 is displaced, we are confronted with a new abnormal type of the Zeeman-effect, of which present theories afford no explanation. A. E.

345. *Modifications caused by a Magnetic Field of the Spectral Rays from the Electric Spark.* **G. A. Hemsalech.** (Comptes Rendus, 151. pp. 938–940, Nov. 21, 1910.)—A description of further work on the modifications produced by a magnetic field of the duration of rays emitted by the luminous vapours of the electric spark. [See Abstracts Nos. 67 (1911), 1488 (1910), 1140 (1908).] As a result of further research, the author now concludes that, under the experimental conditions employed, there is a superposition of two different effects, and by examining by two independent methods the spectra of a series of metals, he has established the existence of the three following phenomena. (i) *The general effect,* which is independent of the orientation of the discharge with respect to the lines of force of the magnetic field; this results in the diminution of the duration, as well as of the luminous intensity, of the rays emitted by the metallic vapour. (ii) *The longitudinal effect*; this produces an increase of the duration of the metallic rays and an augmentation of the brightness of these rays as well as of those of the air. This effect shows itself uniquely when the spark takes place parallel to the lines of force. (iii) *The transversal effect;* this is obtained only with very slow discharges (self-induction in the discharge circuit) when the spark is perpendicular to the lines of force. The effect consists of a prolongation of the duration of certain rays, and it is due to the displacement which, under the action of the field, the oscillation carrying the discharge current undergoes. Its action is very selective. The present paper deals with observations on the first of these effects. Two methods of observation are described: the method of the current of air previously described, and the method of Lockyer, which gives a convenient means of demonstration, the air-current method being better adapted for quantitative work. The diminution of the intensity of the spectra is strikingly shown when the slit of the spectrograph is perpendicular to the direction of the train of vapour; a region can then be obtained such that the observation is not hindered by the brilliant parts of the spectra (the initial discharge). Thus, using a condenser of 0·01 mfd. and sparking between iron electrodes, with a field of only 1000 c.g.s. units, an appreciable diminution of the luminous intensity was observed, especially in the red, yellow, and green parts of the spectrum. With a field of 2000 c.g.s. units the effect extends to the violet and the beginning of the ultra-violet, and the intensity of the whole spectrum is very considerably reduced with a field of 8000 c.g.s. units. The longitudinal effect is obtained in a marked manner with Cd. This effect has an action opposed to that of the general effect, but it shows itself only with very small capacities (from 0·001 to 0·0001 mfd.). For a given value of the capacity—a value which depends on the nature of the metal—the two effects neutralise each other. With large capacities, *i.e.*, with greater quantities of metallic vapour, the general effect predominates. The results obtained may possibly explain certain solar phenomena. It is possible that the fields set up in the surface of the sun by the whirling of electrified particles act on the vapours which they enclose and cause a diminution of their luminous intensity. This would give rise to an increased absorption of the light proceeding from the photosphere, from which would result the reinforcement of certain rays of sun-spots. From the author's observations on the rays of iron, the intensity of the solar magnetic fields (2000 to 3000 c.g.s. units) seems to be sufficient to produce the effect in question. A. W.

346. *Progressive Phosphorescence at Low Temperatures.* **J. de Kowalski.** (Comptes Rendus, 151. pp. 810–812, Nov. 7, 1910.)—Stark discovered the ultra-violet fluorescence of benzene and its substitutes at ordinary temperatures. Ley and Engelhardt have found that most of the substitutes for benzene possess a selective fluorescence in the invisible part of the spectrum. This fluorescence is now studied in alcoholic solutions of different organic bodies of the aromatic series at temperatures varying between −100° and −190° C. Down to temperature −185° nearly all the substances used remain in a liquid state, but become more and more viscous as the temperature is lowered. In this state the fluorescence extends towards the red end of the spectrum. The spectrum of the fluorescence at this temperature is generally composed of very large bands following one another closely, and of different intensity in different parts of the spectrum. Towards −185° the viscous solutions become solid amorphous masses like glass. The fluorescence extends more and more towards the red. Phosphorescence is only noticed generally, at temperatures much lower than that at which solidification takes place (it varies between −150° and −165° according to the substances in solution). At the temperature at which the first appearance of phosphorescence occurs it lasts only some hundredths of a second, but a small lowering of the temperature is then sufficient to bring about a phosphorescence of much longer duration. If the substance is exposed for a very short time (one or two hundredths of a sec.) to the action of light a very bright phosphorescence of very short duration takes place, giving a spectrum almost identical to that due to fluorescence. It is proposed to call this *instantaneous phosphorescence.* The duration of instantaneous phosphorescence increases with the lowering of the temperature, and it depends also on the nature of the substances and on the concentration of the solution. If the substance is exposed continuously to the action of light, spectroscopic analysis shows fine bands superposed upon the large bands in the fluorescence spectrum; the intensity of these progressively augments with the length of exposure, ultimately attaining a limiting value which depends upon the intensity of the exciting rays and on the temperature. The duration of this may attain a value of the order of 100 sec. It is proposed to call this *progressive phosphorescence.* The spectrum of progressive phosphorescence is a well-defined function of the substance dissolved, and varies little with the concentration of the solution. The relative intensity of the different bands of the same spectrum of the progressive phosphorescence depends on the temperature of the source of light employed to excite it. There is a certain temperature for each substance above which progressive phosphorescence does not appear. An experiment is described which seems to prove that this phenomenon has no connection with changes in the electric conductivity of the solidified solution. A. E. G.

847. *Reversal of Bands of Phosphorescence.* **J. Becquerel.** (Comptes Rendus, 151. pp. 981–983, Nov. 28, 1910.)—Certain phosphorescent crystals possess bands common to the spectrum of phosphorescence and to the absorption spectrum. The reversal of the bands can be effected by exciting the phosphorescence of the face of the crystal turned towards the observer, and sending through the crystal a longitudinal beam not containing the excited radiations, thus allowing the absorption spectrum to be obtained in the region where the bands of phosphorescence are found. Thus, in the case of rubies, the light of the first source should contain green and yellow, that of the second only red rays, which are not exciters for the bands situated between 690 μμ and 710 μμ. With a small intensity of the transmitted light the bands or rays of phosphorescence appear very bright on a luminous background; but when the transmitted light is gradually increased while the intensity of the phosphorescence is kept constant, different bands appear, one after another, dark on a luminous background. An account is given of experiments made with different rubies, and with an emerald. The crystals are first plunged in liquid air to cause new bands to appear. The image of a lamina (1 mm. to 2 mm. thick) cut parallel to the optic axis is then projected on the slit of a spectroscope, and by means of a rhombohedron of spar the ordinary and extraordinary spectra are juxtaposed. For the feeble bands, all parts of one and the same band are reversed at the same time, and simultaneously in the two spectra. When the absorption is intense (691·8 μμ and 693·2 μμ for rubies), the edges alone exhibit simultaneous reversal, and the parts near the middle require for reversal correspondingly increased intensity of the transmitted light the greater the absorption. Thus, at the moment the edges of the bands are just reversed, an intense band is bright in the middle with black edges. Very different intensities are required for the reversal of the different bands. All the experiments lead to quantitative results, which are discussed. The simultaneous reversal of all parts of one band shows that the breadth is the same both in the case of emission and of absorption, and proves that at the instant of reversal there is, for all the radiations forming a band, in the two spectra together, equality between the emitted and the absorbed intensity. The results establish not only that certain centres which produce phosphorescence are similar to absorbing centres, but that the orbits of the luminous particles are, on the average, oriented in the same manner in both cases. A. W.

348. *Triboluminescence of Uranium.* **W. A. D. Rudge.** (Nature, 85. p. 207, Dec. 15, 1910.)—Rudge has observed that when a bottle of metallic Ur is shaken a considerable luminescence is produced, the same being observed, but to a much smaller degree, with the nitrate and yellow oxide, while the black oxide and sodium uranate do not give it. **A. C. G. Egerton** (Ibid. p. 308, Jan. 5, 1911) points out that Moissan first directed attention to the pyrophoric properties of metallic Ur, the luminosity being due to oxidation, and not being exhibited in an atmosphere of hydrogen. The luminescence of uranium nitrate when shaken is, however, unabated in hydrogen, and is true triboluminescence. E. M.

349. *Probability Variations in the Distribution of α-Particles.* **E. Rutherford** and **H. Geiger,** with a Note by **H. Bateman.** (Phil. Mag. 20. pp. 698–707, Oct., 1910.)—In counting α-particles emitted from radio-active substances either by the scintillation or the electric method, it is observed that, while the average number of particles from a steady source is nearly constant when a large number is counted, the number appearing in a given short interval is subject to wide fluctuations. The present experiments deal with the question as to whether these variations are in agreement with the laws of probability. In a mathematical note to the paper H. Bateman shows that if x be the true average number of particles for any given interval, falling on the screen from a constant source, the probability that n α-particles are observed in the same interval is given by $x^n e^{-x}/n!$, n being a whole number. In the experiments described polonium was used as a constant source of α-particles, and the value of x was determined by counting a large number of scintillations on a zinc sulphide screen, imperfections of the screen being eliminated in the calculations. The scintillations were recorded on a chronograph tape by closing an electric circuit by hand at the instant of each scintillation, and from an examination of the tape the number of times n scintillations were recorded in a given interval was inferred for values of $n = 0, 1, 2, 3$, &c. Ten thousand scintillations were counted in all, at the average rate of about 30 per min., and these were analysed with respect to the numbers occurring in ⅛- and ¼-minute intervals, and the results were found to be in good agreement with those calculated from the above expression, showing that the variation in the number of α-particles from interval to interval is the same as would be expected in a random distribution. E. M.

350. *Number of α-Particles emitted by Uranium and Thorium and by Uranium Minerals.* **H. Geiger** and **E. Rutherford.** (Phil. Mag. 20.

pp. 691–698, Oct., 1910.)—The material under investigation was deposited as a thin uniform film, and the α-particles emitted by this film were determined by the scintillations produced on a zinc sulphide screen which had previously been standardised by reference to the α-particles emitted by a known amount of RaC. The results obtained were as follows:—

	Number of α-Particles per gm. Ur per sec.		Production of Helium per gm. per year.
	Calculated.	Observed.	
Uranium	$2{\cdot}82 \times 10^4$	$2{\cdot}87 \times 10^4$	$2{\cdot}75 \times 10^{-6}$ mm.^{3}
Uranium mineral	$9{\cdot}67 \times 10^4$	$9{\cdot}6 \times 10^4$	$11{\cdot}0 \times 10^{-6}$ mm.^{3}
Thorium, number of α-particles per gm.	—	$2{\cdot}7 \times 10^4$	$8{\cdot}1 \times 10^{-5}$ mm.^{3}

In the case of Ur the theoretical result was obtained by assuming that 1 gm. Ra emits $8{\cdot}4 \times 10^{10}$ α-particles per sec., and that the amount of Ra in equilibrium with 1 gm. Ur is $8{\cdot}4 \times 10^{-7}$, and also that Ur in its transformation emits two α-particles [see Abstract No. 1100 (1908)]. In the case of the uranium mineral (uranite) a correction was necessary for the small quantity of actinium which Boltwood has shown to be genetically connected with Ra. In the course of the experiments a determination of the range of the α-particle from Ur was made; it was found to be about 2·7 cm., which is less than the result found by Bragg. [See Brown, Abstract No. 1604 (1910).] E. M.

351. *Primary and Secondary γ-Rays.* **D. C. H. Florance.** (Phil. Mag. 20. pp. 921–938, Dec., 1910.)—The paper deals with experiments on the question as to whether the primary and secondary γ-rays from Ra are homogeneous or heterogeneous. Soddy and Russell [Abstract No. 1252 (1910)] have shown that under certain conditions the γ-rays from Ra are absorbed according to an exponential law, and have concluded that they are homogeneous. In the present experiments the author finds that when the γ-rays are incident on radiators of different materials the quality of the emergent radiation varies; but if the right thickness for each radiator be chosen, then the quality of the primary and secondary radiation is independent of the material of the radiator. With any two radiators the ratio of the absorption coefficients keeps approximately constant for any position of the electroscope relative to the radiator. The author finds also that there is a gradual decrease in the quantity of secondary γ-radiation from that which emerges from the radiator in the direction of the original radiation to that which is returned in the reverse direction, and from these and other experiments concludes that the secondary radiation appears to be the scattered primary and to be heterogeneous, thus supporting the view that the primary radiation is heterogeneous. [See also Abstract No. 1716 (1910).] E. M.

352. *Absorption and Reflection of β-Particles by Matter.* **A. F. Kovarik.** (Phil. Mag. 20. pp. 849–866, Nov., 1910.)—The paper deals with a detailed investigation of the variation of the absorption and reflection coefficients of β-particles by matter under different experimental conditions. As sources of β-particles RaD, ThA, RaB, RaE, ActC, ThD, and RaC were used, giving a wide range of penetrating power. The author shows that scattering may under certain conditions produce a considerable rise in the initial portion of the absorption curve and a steep incline under other conditions, while the absorption coefficient was also found to vary with the substance placed underneath the active matter, increasing with its atomic weight, this effect being due to reflection. It was found necessary to put the absorbing material directly against the opening of the electroscope, and to place as many absorbing sheets underneath the active layer of matter as above; while the electroscope used was in the shape of a semisphere, so that all rays might have the same length of path in it [see Abstract No. 1606 (1910)]. Tables are given of the absorption coefficients of various sets of β-rays by different metals under these conditions. In the case of the reflection of β-particles the percentage of reflection by any one substance as measured by the ionisation method was found to be a function of the velocity, increasing at first with the velocity, and decreasing again for very penetrating rays. The percentage of reflected β-particles was found to increase with the atomic weight of the reflector. Similar results were obtained for multiple reflection between parallel plates, the ionisation in some cases being increased 8·5 times in this way. E. M.

353. *Radium-content of Waters of the Cam, of Cambridge Tap Water and some Varieties of Charcoal.* **J. Satterly.** (Cambridge Phil. Soc., Proc. 15. pp. 540–544, Oct. 20, 1910.)—The method employed was to first bubble air through the boiling water to get rid of all the emanation; the vessel containing the water was then closed and the emanation allowed to accumulate for a known time, when it was boiled off and measured by its ionising effect in a standardised ionisation chamber. The results obtained were as follows:—

1 litre tap-water contains $1·6 \times 10^{-12}$ gm. Ra
1 ,, Cam ,, ,, $8·2 \times 10^{-12}$,, ,,
1 ,, Hydrochloric acid ,, 11×10^{-12} ,, ,,

It is also found that in the initial boiling, amounts of emanation corresponding to 130×10^{-12} and $5·0 \times 10^{-12}$ gm. Ra per litre were given off from tap-water and Cam water respectively. These results are greater than that found by Eve for the water of the St. Lawrence, *i.e.*, $0·25 \times 10^{-12}$ [Abstract No. 1412 (1909), &c.], thus explaining the greater Ra-content of the air at Cambridge than at Montreal [see Abstract No. 1445 (1910)]. The author has also made experiments on the Ra-content of some charcoals, and finds $0·8 \times 10^{-12}$ gm. Ra per gm. for wood and cocoanut charcoal, and $1·8 \times 10^{-12}$ for Brazil-nut charcoal, these figures comparing with the average Ra-content of rock, $1·4 \times 10^{-12}$. E. M.

354. *Volatilisation of Radium Emanation at Low Temperatures.* **R. W. Boyle.** (Phil. Mag. 20. pp. 955–966, Dec., 1910.)—Rutherford and Soddy showed that when small quantities of RaEm are condensed on a material surface and a slow current of air is passed over them, with increasing temperature the emanation is suddenly liberated at about −150° C. [Abstract No. 95 (1904)]. Laborde, from his experiments [Abstract No. 1228 (1909)], concluded that the temperature at which this volatilisation takes place is largely influenced by the material on which the emanation is condensed, being −155° in the case of various metals, and about −177° in the case of glass. The author has investigated this latter discrepancy. The emanation was condensed as in the previous experiments on a spiral immersed in cooled pentane and air passed through while the temperature was slowly raised, the amount of emanation carried by the stream of air being measured by an ionisation method. The author finds that with increasing temperature the volatilisation gradually increases until −160° C.; approaching this temperature the volatilisation becomes relatively very rapid, and above it practically ceases. The temperature of max. volatilisation appeared practically the same for metals as for glass, and the author explains Laborde's result as being due to his using a bath of granulated copper and having a large temperature gradient from the bottom of the bath to the top. **E. M.**

355. *Radium-content of Rocks.* I. and II. **E. H. Büchner.** (Konink. Akad. Wetensch. Amsterdam, Proc. 13. pp. 359–365, Oct. 27, 1910, and pp. 818–819, Feb. 28, 1911.)—Rutherford's calculations show that $4·6 \times 10^{-14}$ gm. Ra per gm. of the earth would be sufficient to maintain the thermal equilibrium of the earth, while the experiments of Strutt and others show that on the average the actual quantity present is of the order $1·2 \times 10^{-12}$, *i.e.*, considerably more than the quantity calculated by Rutherford [see Abstract No. 71 (1908)]. In consideration of the importance of this result the author has taken up the investigation of a number of European and Dutch-Indian rocks, these not being fully represented in results so far obtained by other experimenters. In the experimental method employed the amount of RaEm generated by a known quantity of the rock was compared with that generated by a standard Ra solution. A table is given showing the results of the examination of 10 rocks from the west coast of Sumatra, the values of the Ra-content varying from $0·80 \times 10^{-12}$ gm. Ra per gm. of rock for diorite (Ahoer Tampoeroengo) to $13·0 \times 10^{-12}$ for basalt (volcano of Asar). [See also Strutt, next Abstract.] The second paper deals with some sedimentary rocks, four samples of marble, six of limestone, and one of chalk. The following results were obtained as the Ra-content per gm. of rock in gm. $\times 10^{-12}$: Marble 0·8 to 1·7 mean 1·35; limestone, 0·4 (trias, Jena) to 4·3 (carboniferous, Düsseldorf), mean 1·4; chalk (diluvial), 1·5. The results as a whole show little variation and no relation between Ra-content and age. The general mean is 1·4 and agrees fairly well with that obtained from the experiments of other observers except Joly, whose mean value for twelve rocks of this kind is 8·8. This may be due to differences in the methods of determination. **E. M.**

356. *Radium-content of Basalt.* **R. J. Strutt.** (Roy Soc., Proc. Ser. A. 84. pp. 377–379, Oct. 21, 1910.)—In a former paper the author gave measurements on the amount of Ra in representative igneous rocks. The calculation of these results involved the value of the equilibrium ratio between Ra and Ur, which has since been corrected and the amended results published by Eve and McIntosh [Abstracts Nos. 1235 (1906) and 71 (1908)]. The measurements are in substantial agreement with those of subsequent experimenters but differ largely from those of J. Joly, ("Radioactivity and Geology," p. 42, 1909). The discrepancy is most marked in the case of basalt for which Joly finds the mean value $4·9 \times 10^{-12}$ gm. Ra per gm. of rock. The author has therefore made additional measurements on basalts, the standardisations being carried out with several different analysed specimens of uranium ore in practically the same manner as previously. The mean values of the content of Ra, in gm. $\times 10^{-12}$ per gm. of rock, ranged from 0·16 to 0·57. It is possible that the difference between these results and those of Joly is due to his having met with exceptional specimens. **E. M.**

357. *Rate of Production of Helium in Thorianite and Pitchblende.* **R. J. Strutt.** (Roy. Soc., Proc. Ser. A. 84. pp. 379–387, Oct. 21, 1910.)—The method of deducing a minor limit to the ages of minerals from an examination of their radio-active properties has up to the present depended on the amount of He they now contain and on an indirect calculation of the rate at which it is being produced by the radio-active matter within them. The present paper deals with an experimental determination of the rate of production of He in two specimens of thorianite and one of pitchblende. The He was first totally expelled from the specimen by carefully boiling its solution which was then stored in a vacuous flask. When it was desired to collect the gas, the solution was boiled and the gases given off were collected and purified, the final isolation of the He being effected by cooled charcoal. The volume of the resultant He was then determined by a capillary tube and found to be in good agreement with the volume calculated theoretically from the radio-active content, the results thus justifying the indirect calculation method; indicating that some specimens of thorianite are at least 280 million years old. E. M.

REFERENCES.

358. *The Grating Interferometer.* **C. Barus** and **M. Barus.** (Phys. Rev. 31. pp. 591–598, Nov., 1910.)—The rays from a collimator are reflected from a grating and the interference patterns viewed in a telescope. The paper gives an account of the instrument and its adjustment, the angular extent of the fringes seen, and a test of the instrument by measuring the magnetostriction of a rod of soft iron to which the grating was attached. [See also Abstracts Nos. 678, 1268 (1910).] G. E. A.

359. *Construction of Optical Systems.* **H. Harting.** (Zeitschr. Instrumentenk. 30. pp. 359–363, Dec., 1910.)—The author gives working formulæ for the construction of double-lens objectives. C. P. B.

360. *Absorption of Benzol in the Ultra-violet.* **L. Grebe.** (Zeitschr. wiss. Phot. 9. pp. 130–140, Dec., 1910.)

361. *False Relief in Parallax Photographs.* **P. H. Eijkman.** (Zeitschr. wiss. Phot. 9. pp. 195–200, Jan., 1911. Paper read before the Internat. Photographic Congress, Brussels, Aug., 1910.)—The author discusses the varieties of false relief which may be shown on photographs obtained with varying degrees of parallax displacement. The effect becomes of importance in the study of Röntgen X-ray pictures taken with the source of light near the subject. C. P. B.

362. *Secondary Iron Arc Standard Wave-lengths.* **H. Kayser.** (Zeitschr. wiss. Phot. 9. pp. 173–185, Jan., 1911.)—Taking the mean of three observers as primary standards, a series of lines in the arc spectrum of iron has been determined in order to furnish secondary standards for general work. A list of the lines so measured is given, extending from λ4118·553 to λ6494·994. C. P. B.

HEAT.

363. *Thermal Conductivity, and Thermal Resistance and Conductance.* **C. Hering.** (Metallurgical and Chem. Engin. 8. pp. 676–677, Dec., 1910, and 9. pp. 13–15, Jan., 1911.)—The author advocates the use of thermal resistivity rather than of thermal conductivity; he also advocates that a name be given to the unit of thermal resistance, which he considers to be the most rational unit to employ in thermal calculations as there would then be strict analogy between thermal and electric flows. He suggests the name "thermal ohm," the unit to be defined as that thermal resistance which will require a drop of 1° C. for a watt of heat-flow. Specific thermal resistances (that is, resistivities) are then expressed in terms of thermal ohms for a 1-in. or 1-cm. cube. According to the same system thermal conductances should be expressed in "thermal mhos," the unit being defined as that conductance which will allow 1 watt of heat to pass when the difference of temperature is 1° C. Tables of conversion factors are given between these new units, the gm.-calorie units, and the true c.g.s. units. Typical calculations follow showing how the new units simplify the working of problems, and a table of resistivities and conductivities shows that the units are of convenient size for practical use. A. D. R.

364. *Flow of Heat through Furnace Walls.* **F. T. Snyder.** (Amer. Electrochem. Soc., Trans. 18. pp. 235–244; Discussion, pp. 244–258, 1910.)—In this paper the parts played by heat convection and heat radiation in compound furnace-walls are considered. The unit of heat-flow used is the temperature drop in degrees Centigrade per in. of thickness per kilowatt per sq. ft. The radiation of heat from the outside surface varies with the difference between the fourth power of the absolute temperatures of the surface and the air, multiplied by a constant to reduce the results to kilowatts of heat-flow per sq. ft. The convection from the surface is affected by two factors—the transfer resistance of the flow of heat from the surface to the air, and the movement of the heated air away from the surface. The velocity of this movement is in turn determined by the temperature of the surface. The radiation, according to Stefan's law, is, $R = a(T^4 - t^4)$, where R = kw. per sq. ft.; T = hot temperature; t = cold temperature and $a = 0{\cdot}0088 \times 10^{-9}$ for ordinary sheet iron and $0{\cdot}0042 \times 10^{-9}$ for brick and slag. The convection from the surface to the air, as a function of the velocity of the convection currents is given by the formula $C = b(T - t)(2 + 5{\cdot}5\sqrt{v})$, where C = kw. per sq. ft.; T = temperature of furnace surface; t = air temperature; $b = 0{\cdot}00011$ for a sheet-iron shell and $0{\cdot}00015$ for a brick furnace surface; and v = velocity of convection currents in feet per sec. The velocity of the convection currents for the outside of electric furnaces is determined from the empirical formula $v = 0{\cdot}022(T - t)^{3/4}$. A table is given of various refractory materials, showing the temperature-difference required to force a heat-flow of 1 kw. per sq. ft. through 1 in. for different temperature ranges. Details are also given for the calculation of the heat-flow and temperature distribution for a proposed furnace wall, and a numerical example is added showing the calculation of temperature distributions through the bottom of a small steel-furnace.

C. O. B.

365. *Determination of Thermal Conductivities.* **C. Hering.** (Amer. Electrochem. Soc., Trans. 18. pp. 213–222; Discussion, pp. 223–233, 1910. Metallurgical and Chem. Engin. 8. pp. 627–628; Discussion, p. 628, Nov., 1910.)—A new method is suggested for the determination of thermal conductivities of insulating materials over the ranges of temperature used in electric furnace practice. In its ideally perfect form, the method consists in using a hollow sphere of material, filled with a good heat-conducting material such as a molten metal, heated electrically, the outside being surrounded by a suitable liquid and the temperature of the inside and outside recorded by thermometers. This test, properly carried out, should give the absolute thermal conductivity and not merely relative values. The use of the hollow sphere is not very practical, however, and as a more convenient form, a cylindrical cup, rounded at one end and open at the other, is suggested and illustrated. Care must be taken to mould or grind the test cup to the same thickness throughout. For testing loose, granular, or fibrous materials like infusorial earth, sand, asbestos, magnesia, &c., the cup may be made of two thin sheet-iron shells, the material to be tested being placed between. The formulæ necessary for the calculations are given, but the author has not yet had an opportunity of carrying out the method. In a communication, **W. S. Landis** gives some results carried out by a similar method first suggested by Peclet in 1860. These remarks and results are severely criticised in the author's reply. [See also Abstracts Nos. 465, 1028, and 1775 (1910).] C. O. B.

366. *Determination of Specific Heats at Low Temperatures.* **F. Pollitzer.** (Zeitschr. Elektrochem. 17. pp. 5–14, Jan. 1, 1911.)—The specific heats of Zn, Hg, $ZnSO_4 . 7H_2O$, Hg_2SO_4, and HgCl were determined from −210° C. and −190° C. and upwards. The results agree with the values calculated by the Magnus-Lindemann formula. The latent heat of fusion of mercury was found to be 555 cals. at $t = -38·7°$ C. The results were used for the calculation of e.m.f.'s of certain galvanic cells, by the application of Nernst's theorem. For details the original must be consulted. F. J. B.

367. *Calorimetric Apparatus and a Test of Calorimetric Accuracy.* **W. P. White.** (Phys. Rev. 31. pp. 670–685 and 686–701, Dec., 1910.)—In the first article the author describes calorimeters and accessories used for the determination of specific heats. These cannot, however, be understood without the numerous accompanying figures. The calorimeters described were calibrated by the electrical method. The results obtained are given in the second article. It is found that (1) the average accidental error of a complete calorimetric determination has been reduced to about one part in 30,000. The essential conditions for this performance appear to have been; ordinary care in manipulation and observing, an electrical thermometer reading consistently to 0·0003°, auxiliary electrical apparatus accurate to 0·00003°, a complete and uniform enclosure for the calorimeter, regulation of the stirring, elimination of evaporation, and the use of unusually large temperature-intervals. Of these features only the last two are specially characteristic. (2) The average accidental temperature error was brought below 0·00025°. (3) No error due to the cooling correction could be detected, even where the total average error was only 0·00003°. (4) The preponderant accidental calorimetric error was in the temperature measurement. (5) No systematic error due to the calorimeter could be detected. The constancy of the auxiliary electrical apparatus was not great enough to bring the systematic error of

the final result of the calibrator below 0·1 per thousand. (6) The use of a large temperature-interval diminishes the effect of the temperature error. It brings no corresponding disadvantage. Intervals much larger than those ordinarily used are therefore to be recommended where accuracy is desired. A. F.

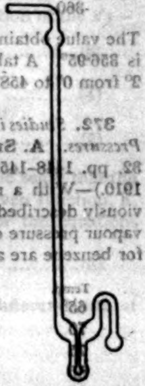
368. *Radiation Errors in Flow Calorimeters.* **J. H. Coste** and **B. R. James.** (Soc. Chem. Ind., Journ. 30. pp. 67-69; Discussion, p. 69, Jan. 31, 1911.)—When water is allowed to circulate through a flow calorimeter without lighting the gas, the temperature of the outlet water will be different from that of the inlet water, due to the heat exchanges with the external atmosphere. If the water-supply is of a lower temperature than the surroundings of the calorimeter, as is usually the case, the outlet thermometer will read from 0·06 to 0·20 degree C. higher than the inlet thermometer. This error is due to the absorption of heat and can be corrected in three ways: (1) By considering the thermometer readings when water is flowing at the desired rate, but no gas burning, as index or zero errors, and by using the observed increased difference between inlet and outlet. (2) By raising the water to the temperature of the room. This may be done by having a water-tank in the room and working from this, with the ball-cock or other inlet from main closed, during an experiment. Another method is to pass the water through coils of piping heated by gas or by chemical action. (3) By surrounding the instrument with an annular metal vessel, through which water circulates, before reaching the inlet thermometer. The jacket which has been constructed is concentric with the outer casing of the calorimeter, and is separated from it by an air space of about ½ in. The best arrangement is to combine methods 2 and 3. In the *discussion,* **G. N. Huntly** pointed out that when tests were being made in a calorimeter there was unequal temperature distribution, and that the radiation would then be different in degree from that obtained when the gas was not alight. For this reason an accuracy greater than ½ to 1 per cent. could not be expected with a flow calorimeter. J. B. C. K.

369. *Low-temperature Research.* **J. Dewar.** (Engineering, 91. pp. 128-134, Jan. 27, 1911. Discourse delivered at the Royal Inst., Jan. 20, 1911.)—Ozone is produced when oxygen, passed through an ozoniser, is bubbled through liquid air, and also by ultra-violet rays acting through a lens directly on liquid (not gaseous) oxygen. When the rays of a quartz mercury lamp are filtered through water (to absorb heat) and act on silver, cooled with liquid oxygen, the silver remains bright until it warms up again; the ozone does not act at extreme cold in that case. But luminous bacteria are killed by ultra-violet rays, even at the lowest temperature, and permanently lose their luminosity, which the cold itself only temporarily destroys (H. Crookes). While liquid nitrogen and hydrogen can both be solidified by ordinary exhaustion, liquid oxygen can be turned into a jelly only by the aid of charcoal and by high isolation in a silvered vacuum vessel; the reason will be understood from the (abridged) table of the pressures (in mm. of Hg) at melting-point temperatures (°C. abs.):—

Helium …………………	below 2 mm.	below 2·5°
Argon …………………	628 „	85°
Hydrogen …………………	50 „	14°
Nitrogen …………………	90 „	59°
Oxygen …………………	0·9 „	46°

The percentage of the rare gases of the air can be determined by the use of cooling agents, and vanishing compounds be isolated in this way. Carbon disulphide forms a colourless liquid, but the supposed monosulphide was so far only known as a brown powder, free of smell, while the analogy of CO_2 and CO would suggest a highly volatile monosulphide. The following demonstration tends to show that the real monosulphide is a very unstable body which at ordinary temperature can only exist for half a minute, because it polymerises into the ordinary brown powder $(CS)_n$. Liquid CS_2 was placed in a tube surrounded by solid CO_2 so as to give off CS_2 vapour at 0·8 mm. of Hg; this vapour was exposed to the silent discharge and then passed through a U-tube standing in liquid air. A brown ring condensed in the U a little above the level of the liquid air outside; when the U was taken out of the cooling liquid it exploded. **H. B.**

370. *Studies in Vapour Pressure.* III. *Static Method for determining the Vapour Pressures of Solids and Liquids.* **A. Smith** and **A. W. C. Menzies.** (Amer. Chem. Soc., Journ. 32. pp. 1412–1434, Nov., 1910. Ann. d. Physik, 33. 5. pp. 971–978, Nov. 10, 1910.)—[See also Abstract No. 1460 (1910)]. The paper deals with (1) the sources of error of a more general character involved in vapour-pressure measurements, viz., errors of temperature, pressure, and the presence of impurities; (2) the older methods employed; (3) the present apparatus; (4) the measurements of the vapour-pressures of water. The apparatus employed by the authors and called by them the isoteniscope, has the form shown in the Fig. When in use it is placed in a large beaker of water or other thermostat, the temperature of which can be maintained constant. The containing liquid which fills the U-bend is the liquid whose vapour pressure is to be measured. In this way the use of mercury is avoided and also smaller differences of pressure in the open and closed limbs of the apparatus are easily detected on account of the smaller density of the liquid. The manipulation (in the case of water) is as follows: Water is distilled into the U-bend; the open limb is connected with an exhaust pump, and the apparatus exhausted until the water boils, at the temperature of the thermostat. In this way air or permanent gas is removed from the liquid and the closed end of the tube. Air is then admitted until the level of the water in the two limbs is the same. The pressure is then read on an open mercury gauge in communication with the open limb of the apparatus, and the barometric height also determined. The whole process can then be repeated. The authors have tested their apparatus with water and have compared their results with those obtained by Holborn and Henning at temperatures of 50–90°. The mean deviation in the pressures was found to be + 0·08 mm., and the mean of the temperature deviations was −0·0068°. A Pt-resistance thermometer was employed. **A. F.**



371. *Studies in Vapour Pressure.* IV. *A Redetermination of the Vapour Pressures of Mercury from 250° to 435°.* **A. Smith** and **A. W. C. Menzies.** (Amer. Chem. Soc., Journ. 32. pp. 1434–1447, Nov., 1910. Ann. d. Physik, 33. 5. pp. 979–988, Nov. 10, 1910. Roy. Soc. Edinburgh, Proc. 30. pp. 521–522, 1909–1910.)—By means of the isoteniscope described in the preceding Abstract, the authors have determined the vapour pressure of mercury at temperatures

of about 250 to 430°. The bend of the isoteniscope was filled with mercury which had been very carefully purified by distillation and by treatment with nitric acid. The results, which appear to be much more consistent among themselves than those of previous investigators, are very closely represented by the equation $\log p = 9{\cdot}9073436 - 3276{\cdot}628/\theta - 0{\cdot}6519904 \log \theta$. The rounded values are as follows :—

Temp.	Press. in mm.	Temp.	Press. in mm.
255°	84·45	370°	956·25
260	95·94	380	1133·0
270	123·02	390	1335·4
280	156·29	400	1566·1
290	196·81	410	1827·6
300	245·85	420	2123·4
310	304·69	430	2456·0
320	374·82	435	2637·5
330	457·85	440	2828·8 (calc.)
340	555·54	445	3031·5 (calc.)
350	669·77	450	3245·0 (calc.)
360	802·62		

The value obtained for the boiling-point of mercury from the formula above is 356·95°. A table is also given of values of the vapour pressure for every 2° from 0° to 458°. **A. F.**

372. *Studies in Vapour Pressure.* V. *Dynamic Method for Measuring Vapour Pressures.* **A. Smith and A. W. C. Menzies.** (Amer. Chem. Soc., Journ. 32. pp. 1448–1459, Nov., 1910. Ann. d. Physik, 33. 5. pp. 989–994, Nov. 10, 1910.)—With a modified form of their bulblet (dynamic isoteniscope) previously described [Abstract No. 1279 (1910)] the authors have determined the vapour pressure of benzene and of ammonium chloride. The rounded values for benzene are as follows :—

Temp.	Press. in mm.	Temp.	Press. in mm.
65°	463	95°	1180
70	551	100	1348
75	650	105	1542
80	757·5	110	1751
85	879	115	1983
90	1018	120	2240

The temperature of the boiling-point at 760 mm. is 80·12°, as determined from the smoothed curve. For ammonium chloride the values are :—

Temp.	Press.	Temp.	Press.
280°	138	320°	447
290	189	330	587
300	252	333·5	642
310	336		

The values obtained by other investigators are compared with the above and sources of error discussed. **A. F.**

373. *Mechanical Interpretation of the Carnot-Clausius Principle. The Case of a Compensated Transformation.* **L. Décombe.** (Comptes Rendus, 151. pp. 1044–1047, Dec. 5, 1910.)—The author, following Helmholz, assumes that a system is defined (1) by the parameters $q_1 \dots q_n$ denoting sensible motions, and slowly varying; (2) the parameters $x_1 \dots x_n$ representing the invisible vibrations which constitute heat and rapidly varying. The external work done is denoted by $\Sigma Q \partial q + \Sigma X \partial x$, the second term in which expresses the heat absorbed by the system; the first term represents mechanical work strictly so called. Further, he defines $U(q, x)$ as the internal potential energy, and L as the semi-*vis viva*. The relations are assumed to be independent of the time. We have then—

$$L = \Sigma A q'_r q'_s + \Sigma B x'_r x'_s + \Sigma C q'_r x'_s \text{ .... } (1),$$

A, B, and C being respectively functions of $q_1 \dots q_n$ and $x_1 x_2$, &c. It is supposed that L is a function of the x's, only as they appear in the term $w = \Sigma B x'_r x'_s$, which represents half the force of the agitation which constitutes heat. Next, applying Lagrange's equations, he obtains equations—

$$d/dt \,.\, (dw/dx') - dw/dx = X - dU/dx \text{ .... } (2),$$

one for each of the parameters x. Multiplying these equations in order by dx_1, dx_2, &c., remembering that, w being a quadratic function of the x's—

$$2w = \Sigma dw/dx' \,.\, x' \text{ .... } (3)$$

and that—

$$dw = \Sigma dw/dq \,.\, dq + \Sigma dw/dx \,.\, dx + \Sigma dw/dx' \,.\, dx' \text{ .... } (4)$$

he obtains—

$$dw = - \Sigma dw/dq \,.\, dq + \Sigma(X - dU/dx)dx \text{ .... } (5).$$

He next assumes the system to be *partially conservative* in the sense that the part of the half *vis viva* which is concerned with heat is a given function, F, of the q parameters, and that we have identically, in virtue of the equations of motion—

$$w = F(qx), \text{ where F denotes some function .... } (6).$$

Then equating dw in (5) to what we obtain by the total differentiation of (6), there results a group of equations of the form—

$$dF/dq = - dw/dq, \; dF/dx = X - dU/dx,$$

of which the latter can be written $X_1 = d(F + U)/dx_1$, $X_2 = d(F + U)/dx_2$, &c. And it follows that $d\Omega = \Sigma d(F + U)/dx \,.\, dx$—a remarkable form. He confines himself now to the case in which the variables x appear in F and U only as they appear in a certain function $\sigma(x)$, and that—

$$d(F + U)/dx = \theta \text{ .... } (10),$$

the temperature. The quantity of heat absorbed $\Delta\Omega$, becomes then—

$$\Delta\Omega = \theta \Sigma d\sigma/dx \,.\, dx, \quad \text{and} \quad \sigma = S(\theta q) \text{ .... } (12),$$

and by solving this for σ, $\Sigma d\sigma/dx \,.\, dx = dS(\theta q)$, which expresses the Carnot-Clausius principle. He says, finally, that the case of non-compensated transformations can be treated by a similar method by introduction of a preliminary hypothesis. The deduction of equation (5) from (4) presents difficulties and requires explanation. But the responsibility is on the author.

S. H. B.

SOUND.

374. *Vibration Curves of Violin Bridge and Strings.* **E. H. Barton and T. F. Ebblewhite.** (Phil. Mag. 20. pp. 456–464, Sept., 1910.)—A continuation of previous work [Abstracts Nos. 448, 1036 (1907), 1298 (1910)]. The violin being mounted horizontally in the usual position of playing, the vertical motions of each upper corner of the bridge are photographically recorded, as well as the motions of the same corners lengthwise along the strings. Each string is dealt with separately, and is either bowed, plucked, or struck. The photographs show that the vibrations of the bridge are more varied than those of the belly. Each of the strings gives a considerable motion to the bridge in spite of the presence of the other three strings which are not sounding, whereas previously only the G-string gave appreciable motion to the part of the belly under examination. The distribution of the bridge's motion is somewhat intricate, the effect of the same string differing according to the method of excitation, probably owing to asymmetries in the structure of the violin. In some cases the motion of the bridge lengthwise of the string shows a frequency double that of the string. E. E. F.

375. *Whispering Gallery Problem.* **Rayleigh.** (Phil. Mag. 20. pp. 1001–1004, Dec., 1910.)—The phenomena of the whispering gallery, of which there is a good and accessible example in St. Paul's Cathedral, indicate that sonorous vibrations have a tendency to cling to a concave surface. They may be reproduced on a moderate scale by the use of sounds of very high pitch ($\lambda = 2$ cm.), such as are excited by a bird-call, the percipient being a high-pressure sensitive flame. Especially remarkable is the narrowness of the obstacle, held close to the concave surface, which is competent to intercept most of the effect. The explanation is not difficult to understand in a general way, and in *Theory of Sound*, § 287, the author has given a calculation based upon the methods used in geometrical optics. The author here presents a treatment of the problem on distinctively wave principles. Thus, in polar co-ordinates (r, θ), sound in two dimensions may be expressed by—

$$\psi_n = J_n(kr)\cos(kat - n\theta),$$

in which ψ is velocity potential, a the speed of propagation, $k = 2\pi/\lambda$, where λ is the length of straight waves of the given frequency, n is any integer, and J_n is the Bessel's function usually so denoted, whose values are then discussed. A numerical example is given in which $n = 1000$, representing approximately the radius of the reflecting circle. Then the vibrations expressed by the equation are practically limited to an annulus of width 20, or one-fiftieth part only of the radius. With greater values of n the concentration in the immediate neighbourhood of the circumference is still further increased. It is afterwards shown that vibrations in a spherical cavity might be similarly dealt with. E. H. B.

REFERENCE.

376. *Measuring Intensity of Sound.* **W. M. Boehm.** (Phys. Rev. 31. pp. 329–331, Oct., 1910.)—After trying several methods the author preferred an arrangement involving the vibration galvanometer and telephone used with a resonator. The galvanometer is tuned to the sound in use. [See Abstracts Nos. 2054 (1906), and 647, 1128 (1908).] E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

377. *Motion of the Ether in Steady Electromagnetic Field.* **S. J. Barnett.** (Phys. Rev. 31. pp. 662–665, Dec., 1910.)—If we admit the existence of the ether and the reality of Maxwell's stresses, the ether within an element of volume dv of an electromagnetic field devoid of matter will be acted upon by a force $dF = \dot{s}dv/c^2$, where $\dot{s}$ denotes the time derivative of the Poynting vector and c the speed of light. Hence, on the above hypothesis, the ether, when it becomes the seat of a steady electromagnetic field, must be set into persistent motion in the direction of the energy stream. In the experimental work here recorded the electromagnetic field was produced between two horizontal parallel copper bars HI over 2 m. long, and two similar bars KJ, so arranged that the energy stream could be sent along the bars in either direction HIJK or KJIH at will. The state of motion of the ether in this field was investigated by an interferometer of the general type used by Michelson and Morley and by Lodge. The total length of field traversed by such beam of light was about 425 cm. If the velocity of the ether is denoted by u, and the length of path in the field by l, the retardation of one of the beams over the other is $T = 2ul/c^2$ nearly, whence it was found that the smallest velocity that could have been detected was $u = 18$ cm./sec. Currents from 40 to 80 amps. or more were used, involving values of E and H up to about 100 volts/cm. and 15 gauss. In neither case was a lateral shift observed on reversal. Hence it must be inferred that the ether did not move along the energy stream with a velocity so great as ½ m. per sec. E. Cunningham [Abstract No. 124 (1910)] has concluded that if electromagnetic momentum can be regarded as ether momentum, the ether, in the case here considered, must have a velocity u given by—

$$u = \frac{c^2 + u^2}{c} \cdot \frac{EH}{E^2 + H^2},$$

where E and H are expressed in the gaussian system. The solution of the equation is $u = cE/H$ or cH/E. In the present experiments E was about ⅓ electrostatic unit, and H about 17 electromagnetic units, when the current was 90 amps. For this case, therefore, these solutions give for the velocity of the ether either one-fiftieth that of light, or fifty times that of light—both entirely discordant with the results of direct observation. The investigation accordingly appears to be decidedly in favour of the principle of relativity.

E. H. B.

378. *On the Distribution of Electricity in Equilibrium in Conductors.* **E. Almansi.** (Accad. Lincei, Atti, 19. pp. 557–561, Dec. 4, 1910.)—The problems of electrostatics dealt with in this paper are: Problem I.—to distribute a mass M on the closed surface σ of a conductor, in such way that the force F, due to the distribution, shall be zero at all internal points. Problem II.—to distribute the mass M on the closed surface σ in such way that at all points in the space S_0, bounded by a closed surface σ_0 wholly within σ, and as near σ as may be, but not having any point in common with σ, the force F shall not exceed a certain superior limit ϵ. The author justifies this statement of the second problem on the ground that we cannot experiment at *all* points within a closed surface σ, because in practice it must be bounded by a shell, of which the mathematical closed surface σ is only the outer boundary, and our experiments must be made within the inner boundary. He then considers a system of three closed surfaces, σ the outermost, τ within σ, and σ_0 within τ. If dn represents an element of the normal to σ, measured outwards, and ϕ denotes the potential of a mass M, distributed on τ, then by a known theorem—

$$-\int d\tau \frac{1}{4\pi}\frac{d\phi}{dn} = \mathrm{M}, \quad \text{and let} \quad \frac{1}{4\pi}\frac{d\phi}{dn} \text{ be denoted by } h.$$

Let ϕ_1 be a function derived from ϕ according to the law $\phi_1 = \phi - ap$, in which p is the potential of two masses $+1$ and -1, $+1$ being at the point Q on the surface τ, at which U, the potential of the distribution on σ, is maximum, -1 at Q′, where U is minimum; also a is a constant defined later—that is, ϕ_1 is in fact the potential of a mass equal to M, distributed over τ, and of the two masses $+1$ and -1 at Q and Q′. Again, as ϕ_1 is given by $\phi_1 = \phi - ap$, so $\phi_2 = \phi_1 - a_1p_1$, and generally $\phi_{i+1} = \phi_i - a_ip_i$ ... (2). Let—

$$\Delta\phi = (d\phi/dx)^2 + (d\phi/dy)^2 + (d\phi/dz)^2.$$

Also let—

$$\mathrm{B} = \int_s \left(\frac{d\phi}{dx}\frac{dp}{dx} + \frac{d\phi}{dy}\frac{dp}{dy} + \frac{d\phi}{dz}\frac{dp}{dz}\right), \quad \mathrm{C} = \int_s \Delta p,$$

also—

$$\mathrm{A} = \int_s \Delta\phi, \quad \text{similarly} \quad \mathrm{A}_1 = \int_s \Delta\phi_1 \ldots \mathrm{A}_i = \int_s \Delta\phi_i.$$

Then since—

$$\phi_1 = \phi - ap \ (2),$$

$$\Delta\phi_1 = \Delta\phi - 2a\mathrm{B} + a^2\mathrm{C} \text{ by differentiation,}$$

that is—

$$\mathrm{A}_1 = \mathrm{A} - \alpha, \quad \text{if} \quad \alpha = 2a\mathrm{B} - a^2\mathrm{C} \ \ldots\ldots\ldots\ldots\ldots\ldots (5).$$

Let the constant $a = \mathrm{B/C}$, then $\alpha = \mathrm{B}^2/\mathrm{C}$. Now if r, r' be the distances of any point in space from Q, Q′ respectively—

$$p = 1/r - 1/r',$$

and—

$$\mathrm{B} = -\int p\frac{d\phi}{dn}d\sigma, \quad \mathrm{C} = -\int p\frac{dp}{dn}d\sigma,$$

that is—

$$\mathrm{B} = 4\pi(1/r - 1/r')h\,d\sigma = 4\pi\left(\int \frac{h}{r}d\sigma - \int \frac{h}{r'}d\sigma\right)$$

$$= 4\pi\mathrm{D} \quad \text{if} \quad \mathrm{D} = \int \frac{h}{r}d\sigma - \int \frac{h}{r'}d\sigma.$$

Also by (5)—

$$\alpha = 2a\mathrm{B} - a^2\mathrm{C} = \mathrm{B}^2/\mathrm{C} = 16\pi^2\mathrm{D}^2/\mathrm{C} \quad \text{and} \quad \mathrm{D}^2 = \mathrm{C}\alpha/16\pi^2.$$

Similarly $\mathrm{D}_i^2 = \mathrm{C}_i\alpha_i/16\pi^2$. Now in the expression for B, namely—

$$\mathrm{B} = 4\pi\left(\int_i \frac{h}{r}d\sigma - \int \frac{h}{r'}d\sigma\right),$$

the quantity within brackets is the difference between the values which the potential of M distributed over σ has at the points Q and Q′ respectively, that is, between the greatest and least values which U, the potential of the distribution on σ, has on the surface τ. If this difference is denoted by D, $\mathrm{B} = 4\pi\mathrm{D}$, and by (5) $\alpha = 16\pi^2 D^2/C$. The author then remarks that the surfaces σ and τ have no point in common. Therefore there exists a finite superior limit of p, and therefore also a finite superior limit of dp/dn, for any point we choose on σ, and whatever be the points Q and Q′ on τ. Therefore also a finite superior limit of C. Call this limit L. Then $D^2 = L\alpha/16\pi^2$. Similarly $D_i^2 = L\alpha_i/16\pi^2$. Here D_i represents the difference between the greatest and least values which U_i, the potential of M distributed over σ, can have on τ, and α_i is the difference between A_i and A_{i+1}. And since $A_{i+1} = A_i - \alpha_i$, A_{i+1} is equal to or less than A_i. But $A \ldots A_1 \ldots A_{i+1}$ are essentially positive, because C is essentially positive, and $\alpha = 16\pi^2 D^2/C$. Since the surfaces σ and τ have no point in common, therefore by the formula $A_{i+1} = A_i - \alpha_i$, A_{i+1} must be either equal to or less than A_i. But since the quantities A are essentially positive, therefore, as i increases the quantities A diminish, and tend to a definite limit. Therefore also the difference between A_{i+1} and A_i tends to zero. From these data the author reasons as follows: Since D_i is the difference between the greatest and least values of U_i on τ, therefore it represents the difference between the greatest and least values which U has in the space T which is bounded externally by τ. Therefore as i increases the difference between the values of U_i in any two points of T tends to zero. If K_i is the value which U_i has at a fixed point in T, and $K_i + u_i$ its general value at any point in T, as i increases u_i tends to zero at all points within T. If ρ be the least distance between the surfaces τ and σ_0, and P any point in the space S_0 bounded by σ_0, we may describe a sphere of radius ρ, wholly contained within T. Then u_i, which is a regular harmonic function, and du_i/dx, &c., its derivatives, can at any point within the sphere, and especially at its centre, be expressed in terms of the corresponding values at the surface of the sphere, and as the latter tend to zero with increase of i, so also do the derivatives of u_i, and therefore also the derivatives of U_i. But the last-mentioned derivatives are the forces exerted by the distribution of M on σ. We must then, as i increases, ultimately arrive at a value of i for which the last-named forces cannot exceed a superior limit, however small. Thus the problem is solved. S. H. B.

DISCHARGE AND OSCILLATIONS.

379. *On the Protection afforded by Faraday Cubes; especially for Lightning Arresters.* **F. Neesen.** (Deutsch. Phys. Gesell., Verh. 12. 22. pp. 939–948, Nov. 30, 1910.)—This is an account of a number of laboratory experiments to determine to what extent a Faraday network shields buildings from lightning discharge. Through one face of a metal box could be passed a metal rod until it touched the opposite face. A Leyden jar, connected to an influence machine, could be allowed to discharge on to the box, the rod, box, and outer coating of the jar being earthed. The author finds that, as the rod is withdrawn from the face of the box, the protection to side discharge from the box decreases. Experiments are also undertaken to find the effect of varying the resistance of the conducting wires and of surrounding the box by a larger one. From the results of these experiments he draws certain conclusions about the protection of buildings from lightning. The stretching of a protecting network over a building ought not to diminish the distance to the parts in danger. It is not recommended to connect two networks directly one with the other. Also, small changes in earth resistance can bring about considerable changes in the path of the lightning discharge. W. C. S. P.

380. *Intermittent Discharge through Rarefied Gas in Magnetic Field.* **T. Collodi.** (Accad. Lincei, Atti, 19. pp. 637–641, Dec. 18, 1910.)—Using a cylindrical tube and a large kathode the author obtains Righi's magnetic rays [see Abstract No. 952 (1908)] much more clearly when producing the current by an induction coil than by an electrical machine, but the use of the latter is improved by placing a capacity in series. The magnetic rays cause a retreat of the positive stratifications towards the anode, which the author explains by the breaking-up of the binary bodies into their constituent ions where the magnetic field is weak, with consequent increase in the conductivity of the gas. The effect of the magnetic field upon the discharge p.d. is also studied. With cylindrical tube and terminals at the ends, a weak magnetic field lowers the discharge p.d. As the field increases, the potential reaches a minimum and then rises, but does not attain its initial value. With higher rarefaction the phenomenon is less marked, the minimum eventually disappearing and the p.d. rising continuously. With the anode in a side-tube there is a rise before the minimum, but with increasing rarefaction the phenomenon becomes as before. The above explanation for the case of the magnetic rays is applied to this case. S. G. S.

381. *Discharge in Electrodeless Tubes.* **H. Brusch.** (Ann. d. Physik, 33. 6. pp. 1116–1138, Dec. 20, 1910. Extract of Dissertation, Berlin.)—The alternating-current discharge inside glass tubes without electrodes is investigated. The ends of the glass tube may be of ebonite, glass, or sealing wax, and the discharge takes place between these. The nature of the discharge is found to be closely analogous to alternating-current discharge in tubes with electrodes. During each half-period a great number of separate discharges take place. The discontinuity of the discharge is shown to affect the anode- and kathode-fall. The curves giving the variation of these with pressure show that the anode-fall rises to a maximum at a certain pressure as the pressure is decreased, while at this same pressure the kathode-fall is a minimum. The kathode-fall is much less affected than the anode-fall. The latter is of the same order as for metal electrodes. The kathode-fall for glass is about 140 volts, while for sealing-wax and ebonite it is about 260 volts, *i.e.*, of the same order as for metal electrodes. The potential curve inside the tube is analogous to that inside tubes with electrodes.

T. P. B.

382. *Discharge of Electricity through Gases at various Temperatures.* **R. F. Earhart.** (Phys. Rev. 31. pp. 652–661, Dec., 1910.)—In a previous paper [see Abstract No. 1741 (1909)], some experiments were described in which attempts were made to ascertain the potentials required to produce and maintain a luminous discharge through the air and other gases, at temperatures between −78° and 815° C. In those experiments the electrodes consisted of flat parallel discs contained in a chamber of limited dimensions, but with no insulation which would prevent a discharge occurring from the edges of the discs. Two forms of apparatus are now described, one of which can be used for temperatures up to 600° C., and the other for still higher temperatures. The essential point about the new form of apparatus is, that it is possible to assume that the volume of the gas through which the discharge passes is limited to the volume of gas contained between the electrodes. The general conclusions arrived at are: (1) The potentials required to produce a luminous discharge from temperature 22 to 600° C., depend merely upon the mass of gas between the electrodes. (2) The potentials required to maintain

a discharge in air do not fall below 345 volts until temperatures approaching 1000° C. are reached. (3) The minimum energy required to ionise a gas by collision depends to a very slight extent upon the temperature of the gas, for temperatures less than 1000° C. At 1000° the minimum potential required to produce a discharge has only fallen to 355 volts. It was also noted that for pressures less than the critical pressure the potentials for maintaining the discharge increased when the pressures became so low as to require potentials larger than the minimum for the production of the discharge.
A. E. G.

383. *Vector Diagrams of Oscillating-current Circuits.* **A. E. Kennelly.** (Amer. Acad., Proc. 46. No. 17. pp. 373–421, Jan., 1911.)—The author describes novel vector diagrams applicable to oscillating-current circuits. He summarises his conclusions as follows. The orthogonal-projection or rotating-crank vector diagram of the ordinary alternating current can be extended so as to include an oscillating current. With the aid of stationary vector diagrams, the principal features of any given oscillating-current problem can be readily expressed and examined. By making the above stationary vector diagrams rotate and applying the proper damping factor, the process of oscillation can be visualised. By interpreting the diagrams and formulæ hyperbolically, the corresponding properties of the ultra-periodic case can be readily found and examined. That is, the rotating-crank vector-diagram of the ordinary alternating current applies by extension to the non-oscillatory ultra-periodic condenser circuit. The properties of the condenser circuit, whether oscillatory or ultra-periodic are intimately connected with a certain angle $\cos^{-1}a$ or $\cosh^{-1}a$ connected with the circuit constants. The polar co-ordinate type of vector diagram is not so conveniently adapted to the oscillating-current circuit as the crank-projection diagram. The aperiodic case can be treated as the limiting case either of the oscillatory or of the ultra-periodic circuit.
A. R.

384. *Energy Losses in Condensers in High-frequency Circuits.* **J. A. Fleming and G. B. Dyke.** (Phys. Soc., Proc. 23. 2. pp. 117–134; Discussion, pp. 142–146, Feb., 1911. Electrician, 66. pp. 658–660, Feb. 3, 1911. Abstract.)—The secondary circuit, in which is the condenser under test, is excited by "impact" from a primary circuit in which is a Peukert discharger [see Abstract No. 260B (1910)]. Since excitation is by impact and the secondary circuit is non-radiative, the damping in the secondary circuit is due only to resistance and to energy losses in the condenser. A hot-wire ammeter of the type described in Abstract No. 259B (1910) is inserted in the secondary circuit. The resistance of this ammeter is known and resistances of the other parts of the secondary circuit are calculated. Thus from two readings of the ammeter, with and without a known resistance added to the circuit, the equivalent resistance of the condenser is found. In all cases this resistance increases with the condenser current. The observed power loss, D, is related to the corresponding electric force, E, by a formula of the type $D=xE^{y}$. In the case of an oil condenser of variable capacity, the exponent y remains the same, as long as the same oil is used, while the multiplying factor x varies nearly inversely as the capacity or directly as the current-density. The losses in air condensers are by no means zero, but they are immensely less than the losses in glass or ebonite condensers for equal volumes of dielectric but not much less for equal values of the electric force. In the case of air and oil condensers the losses amount to several thousand microwatts per cm.^{3} for electrostatic forces of about 600 volts per cm. With glass or ebonite dielectrics the losses may become very large for much smaller electrostatic forces than this. T. P. B.

385. *Frequency of Electrical Oscillation affected by Metal of Spark-gap* **D. Roschansky.** (Phys. Zeitschr. 11. pp. 1177–1181, Dec. 8, 1910.)—Theory of the action of the spark-gap is developed to explain some experimental results of Wien [see Abstract No. 975 (1910)]. If the curve giving the p.d. between the two sides of the spark-gap is unsymmetrical about the middle point of a half-period, a formula is developed from which the change of frequency may be calculated from the asymmetry. Oscillograms given show that the asymmetry increases as one passes down Wien's series, Mg, Bi, Cd, Zn, Al, Cu, Ag. Mg gives a symmetrical curve and Wien found it did not affect the frequency. The asymmetry increases as the oscillation dies out, and thus the period does not remain constant throughout one wave-train. This would cause a flattening-out of resonance curves just as increased damping does. The change of frequency calculated from the oscillograms is less than that observed by Wien, but the frequency employed is lower and only the lower limit of the change of frequency is obtained. The formula agrees with Wien's observation that the change of frequency is greater for short spark-lengths than for longer ones. T. P. B.

386. *Theory of Electrical Oscillations in Coupled Circuits.* **G. W. Pierce.** (Amer. Acad., Proc. 46. No. 18. pp. 293–322, Jan., 1911.)—The paper gives a solution of the equations representing the flow of electricity in two inductively coupled circuits, when one of these is excited by a persistent high-frequency e.m.f. of sine form. The theory involves (1) a determination of the adjustments that must be made to obtain resonance, (2) a determination of the adjustment for best resonance, (3) a determination of the effect of the resistances on the resonance relations and on the amount of current receivable, (4) a discussion of the resistance that a detector must have for greatest sensitiveness. For best resonance the period of each circuit must be adjusted, the right period being determined by the damping factors and the coefficient of coupling. With given values of the coefficient of coupling and the damping factors the adjustment for best resonance is, in general, double-valued. When two coupled circuits in wireless telegraphy are in tune for best resonance with a certain detector and a change is made to a detector of a different resistance, it is necessary to shift the wave-length of both of the circuits in order to bring the system back to its best adjustment. A high-resistance detector involves a less sharp resonance. It is therefore better to use a low-resistance detector, provided it have a large efficiency in converting electric energy of rapid alternations into energy of direct current. The results are fully illustrated with numerical examples and curves, and are applied to explain some experimental results obtained by the author with a damped impressed e.m.f. [see Abstract No. 1274 (1905)]. T. P. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

387. *Conduction of Electricity in Crystals at High Temperatures.* **C. Doelter.** (Zeitschr. Anorg. Chem. 67. 4. pp. 387–397, July 28, 1910. Extract from Akad. Wiss. Wien, Sitz. Ber. 118. I. 1910.)—Crystals can be divided into the following groups: (A) Those which from ordinary temperatures

upwards show electronic (metallic) conduction without ionic (electrolytic) conduction, *e.g.*, galena, pyrites, ferric oxide, magnetic oxide. (B) Those which are insulators at ordinary temperatures, but become metallic conductors at 400–500° C., *e.g.*, zinc blende, molybdenite, stibnite, wolframite. (C) Those which do not show any marked polarisation, but at high temperatures *probably* conduct in both ways, *e.g.*, quartz, crysoberyl, tin-stone. (D) Those which are insulators at ordinary temperatures, but become electrolytes when heated and show marked polarisation, *e.g.*, sapphire, the silicates, barytes. T. M. L.

388. *New Method for Absolute Measurement of Electric Quantity.* **B. McCullom.** (Bureau of Standards, Bull. 6. pp. 503–527, Nov., 1910.)—[This method was described and put into practice by Blondlot [see Abstracts Nos. 1502 (1899) and 309 (1900)], and the principle was applied to the construction of electricity meters.] The instrument described consists of a relatively large fixed coil with its axis in a horizontal position. At the centre of this fixed coil a movable coil is suspended and the two are concentric when the movable coil is at rest. Attached to the suspended coil is a cylinder of some homogeneous material placed with its axis vertical and coincident with the axis of suspension. The form of the field due to the fixed coils is such that the restoring couple is directly proportional to the angular displacement, and there results a torsion pendulum subject to the laws of a damped oscillation. If K is the moment of inertia of the moving system, T_1 its period when the current i is flowing through the coils, and T_2 the period when the circuit is broken, we have $i=(2\pi/T_1\ \sqrt{(K/C)(1-T_1^2/T_2^2)}$, where C is a constant of the coils. T_1 may be written t/n where t is the total elapsed time and n is the number of vibrations occurring during that time. We then have $it=Q=2\pi n\sqrt{(K/C)(1-T_1^2/T_2^2)}$, where Q is the total quantity of electricity which has passed through the instrument while the movable system has made n vibrations. F. E. S.

389. *Sensitive Thermopile.* **B. J. Spence.** (Phys. Rev. 31. pp. 666–669, Dec., 1910.)—The author wishing to devise and construct a very sensitive thermopile, equal in that respect to a bolometer, and steadier, has accomplished the task as follows. The two elements of the thermo-cells were: (1) An alloy of Bi with 5 per cent. Sn, and (2) an alloy of Bi with 3 per cent. Sb. A single pair of these alloys gave a thermo-e.m.f. of 120×10^{-6} volt per degree difference over a wide range of average temperatures. The bars were small and the pile mounted in hard rubber and cased in a water-jacket. One thermopile having 37 hot junctions had bars 2·5 mm. long and gave $4{\cdot}4\times10^{-3}$ volt per degree difference, the resistance being 5 ohms. This thermopile, connected to a galvanometer of 8 ohms and a sensibility of 4×10^{-10} amp., would give 1·4 mm. deflection for one-millionth of a degree, whereas a Rubens thermopile gave 0·4 mm. deflection with a more sensitive galvanometer. Or the sensitiveness may be expressed as follows: Using the same galvanometer, a candle at a distance of 3 m. from the thermopile gave a deflection of 260 mm., equivalent to a deflection of 2340 mm. for a candle at 1 m. E. H. B.

ALTERNATING CURRENTS AND MAGNETISM.

390. *Magnetic Alloys from Non-magnetic Materials.* **A. D. Ross** and **R. C. Gray.** (Roy. Soc. Edinburgh, Proc. 31. pp. 85–99, 1910–1911. **A. D. Ross.** (Inst. of Metals, Journ. 4. pp. 68–86; Discussion, pp. 87–91, 1910. Engineering,

90, pp. 646–648, Nov. 4, 1910.)—The author describes a series of magnetic tests carried out on Cu-Mn, Cu-Al, Mn-Sb, and Mn-B alloys, and on the ternary alloys of Cu and Mn with Al, Sn, Sb, or Bi with a view to determining the magnetic properties of various intermetallic compounds, and the effect of heat treatment and variation in composition on the magnetic properties of the ternary alloys. Alloys were prepared from the purest materials obtainable commercially by fusing in Salamander crucibles under a layer of barium chloride and casting into rods; the compositions of the latter were determined by analysis and the magnetic properties by means of a Gray-Ross magnetometer. Of the Cu-Mn-Al and Cu-Mn-Sn alloys, those containing 62 Cu, 25 Mn, and 12·5 per cent. Al (No. 2), and 48·4 Cu, 18·1 Mn, and 40·0 per cent. Sn were the most strongly magnetic. The magnetic properties of these alloys are improved by cooling to −190° C., which is interesting in view of the fact that most magnetic metals are less susceptible to magnetisation at low temperatures. Annealing at 150–200° C. improves the majority of the alloys, firstly by removing strains, and secondly by bringing the material into a new and stable condition of equilibrium. This constitutional change is only effected by 6 or 8 hours' baking, but excessively prolonged heating has an adverse effect. Quenching from high temperatures deteriorates the magnetic qualities of the Cu-Mn-Al alloys, but greatly reduces the hysteresis, *e.g.*, the alloy No. 2 shows a coercive force of $< 0{\cdot}3$ c.g.s. unit, that of soft iron being 1·7, while its permeability is still equal to that of cobalt, after quenching from 550° C. In this condition it approaches the ideal magnetic material in having a high permeability and low hysteresis, but the alloy is too brittle and hard to work well. The quenched alloys are in a metastable condition and gradually revert to their original condition after standing several months at room temperatures. Quenching from moderate temperatures has little effect on the copper-manganese-tin alloys, but all alloys are more sensitive to temperature-changes, in the quenched condition. Copper-manganese-antimony alloys are similar to the Al alloys, but the Bi alloys show an increase of susceptibility, retentivity, and coercive force, on quenching from 300° C. The Mn-Sb system is more magnetic than the Mn-B system, the alloy corresponding to Mn_3Sb_2 being fairly magnetic. Copper-aluminium and copper-manganese alloys are only very feebly magnetic; a 30 per cent. Mn alloy shows an increase of retentivity after quenching. The theory that the magnetic properties are due to the existence of ternary compounds, is rejected and the author considers them to be due to the formation of solid solutions of which Cu_3Al is an essential constituent. Mn_3Al is the most magnetic alloy of the binary system, and it is feasible that the ferromagnetism of the ternary system is due to the formation of solid solutions of Cu_3Al and Mn_3Al. In the Cu-Mn-Sn system, which has been found to give rise to two magnetic groups, a similar solid-solution hypothesis is applicable, since Mn forms two compounds with tin, viz., Mn_4Sn and Mn_2Sn. There is at present no direct explanation of the formation of solid solutions adding to the magnetic properties of alloys, but analogous cases are known in the case of iron alloys.

F. C. A. H. L.

391. *Secular Variation of Terrestrial Magnetism.* **F. Bidlingmaier.** (Phys. Zeitschr. 11. pp. 1216–1222, Dec. 15, 1910.)—After giving statistics as to the amount of secular change in terrestrial magnetism, the author refers to the theory which ascribes the variation to slight changes in underground temperature causing portions of the earth's material to rise above or fall below the critical temperature for magnetic properties. Calculations based on permeability-temperature curves of magnetic materials and on our knowledge of the increase of temperature with depth in the earth's crust, show that at a depth of about 25 km. we should find a temperature about the critical temperature of most substances. From observations on the relative amounts of secular change of magnetism in continental and oceanic regions the author deduces a depth of 20 to 25 km. as that at which the secular variations are produced—a result in close agreement with the other method. A. D. R.

392. *Simultaneity of "Abruptly beginning Magnetic Storms."* **O. Krogness.** (Nature, 85. pp. 170–171, Dec. 8, 1910.)—The author criticises the data from which Bauer has found evidence that magnetic storms do not begin simultaneously all over the earth. These data are chiefly derived from observations of storms of the Birkeland "positive equatorial" type. [See Abstracts Nos. 998, 999 (1910).] Later, Faris made another investigation and came to the same conclusion as Bauer [Abstract No. 1388 (1910)]. The chief point appears to be the probable error of a time determination from the photographic records. On the Potsdam records an hour of time is represented by about 20 mm. Taking into account the type of definition, changes in paper on developing, &c., it would appear that when there are no automatic time-marks on the curve itself 1 min. will be the lowest limit of accuracy attainable by measurement. In the study of the equatorial storms the deflections of H are chiefly considered, as their points of commencement are more definite than those of D or Z. From a comparison of the time-differences between America and Potsdam for notable magnetic storms during 1906, 1907, and 1908, it is shown that all the differences are considerably below the error limit as estimated above. In the present author's opinion this indicates the probability that the magnetic impulse occurs simultaneously at all the stations. A quotation is given from Birkeland supporting the same view of the matter. In spite of this Bauer holds that by taking groups of means he can demonstrate time-differences which would prove that the cause of the perturbation was transmitted eastward at a rate of 6,400 miles per min. To remedy this somewhat uncertain condition of affairs it would be comparatively easy to establish at least three stations with very sensitive apparatus provided with accurately adjusted automatic time-marks upon the curve itself. It would only be necessary to do this for the H component to settle the matter. C. P. B.

REFERENCES.

393. *Theory of Damping of Electrical Oscillations.* **M. K. Grober.** (Phys. Zeitschr. 12. pp. 121–124, Feb. 15, 1911.)—A mathematical paper in which a rigid integration of the differential equation for an inductively coupled oscillating system is given. The heating effect in a measuring instrument in the secondary is worked out and the integrals are calculated for certain values of the damping factors of primary and secondary in the neighbourhood of the resonance point. Curves are given showing results. A comparison with other methods shows that the Bjerknes method gives result which are free from objection, in spite of approximations. T. P. B.

394. *Electric Absorption of Certain Alcohols.* **P. Beaulard.** (Comptes Rendus, 151. pp. 55–57, July 4, 1910.)—Gives the results of measurements made by the author's method, using a suspended ellipsoidal quartz receptacle as container for the liquid. L. H. W.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

395. *Hardening of Carbon and Low-Tungsten Tool-steels.* **S. N. Brayshaw.** (Inst. Mech. Engin., Proc. 2. pp. 517–675; Discussion and Communications, pp. 676–710, March–May, 1910. Engineering, 89. pp. 524–529, April 22, and pp. 559–562, April 29, 1910. Abstract.)—This paper deals with the results of a research on the hardening of two carbon tool-steels, one containing about C 1·16, Si 0·1 to 0·2, Mn 0·3 to 0·4 per cent., the other differing by containing 0·5 per cent. W in addition. The bars were heated in the author's salt-bath furnaces, which are described, and in which a mixture of the chlorides of sodium and potassium was used. The pyrometric installation consisting of resistance pyrometers is described. Heating and cooling curves of low-tungsten steel are given, and from these it is concluded that if the temperature has been raised to or beyond 880° the point of subsequent recalescence is lowered. The influence of the max. temperature and rate of cooling upon the recalescence is discussed, and it is shown that: (1) The recalescence of low tungsten steel takes place gradually at 781°, and more readily at 725°, but the recalescence is very much retarded if the steel is cooled from 890°. (2) There is a post-recalescence condition of low-tungsten steel reached by first heating above the halt Ac 1, 2, 3, and then immediately soaking at certain temperatures between the halts Ac 1, 2, 3, and Ar 3, 2, 1. When the steel is quenched from this condition it is softer than the same steel when quenched after soaking between the temperatures mentioned without having undergone the previous higher heating. The effect of heating to various temperatures on the bending-test is described, and the following conclusions are drawn: (1) The complete hardening of both steels is accomplished within a range of 6°, the hardening point coinciding with the halt Ac 1, 2, 3. (2) After the temperature has been raised more than 20 or 30° above the hardening point, the hardness of the steel is lessened by further increases in the temperature, provided the heat is sufficiently prolonged for the steel to acquire thoroughly the condition pertaining to the temperature. (3) There is a change-point at about 880° C. in low-tungsten steel and at a somewhat higher temperature in carbon steel; one of the indications of this change-point is the shortening of bars hardened in water from temperatures below the point, whereas the bars lengthen if this temperature be exceeded at the time of quenching. (4) Practically the same results are obtained by heating low-tungsten bars to any temperature between 760 and 940° and quenching in oil. The effect of heating to various temperatures for various lengths of time is dealt with, and the following conclusions are drawn: (1) Prolonged soaking up to 120 min. at temperatures at which the hardening change is half accomplished in 30 min. does not suffice to complete the change. (2) Prolonged soaking for hardening at a temperature of about 760° has a slightly injurious effect. (3) At a temperature of about 810° a great degree of hardness is attained after a short time of heating, but this hardness is impaired with 30 minutes' soaking. (4) Prolonged soaking at a temperature of about 880° has a seriously injurious effect. The temperature of the brine for quenching is an important matter, and it is shown that both kinds of steel, when quenched in brine at 5° C. are decidedly harder than when quenched in brine at 24°, and quenching in brine at 51°

renders the bars much softer. The effect of various annealings has been determined, and it is shown that: (1) The elastic limit of the tungsten bars hardened at 760 or 860° varies greatly according to the annealings they have undergone. (2) The elastic limit of the carbon bars when annealed at 700 or 940° and hardened at 760 or 860° does not vary to nearly the same extent as with tungsten bars. (3) The hardness of the tungsten bars hardened at 760°, decreases from a high figure to a low one as the temperature of the previous annealing increases from 700 to 940°. (4) The hardness of the tungsten bars hardened at 860° is fairly constant and high whatever the temperature of annealing was. Two furnace heats for hardening are described in which the bars are first heated in one furnace to a certain temperature for a given time and then immediately, without intermediate cooling, soaked in a second furnace at a known temperature for a given time and the results on the elastic limit, max. stress, and hardness noted. The change in length due to annealing is referred to, and it is shown that a slight shortening occurs at temperatures of 800° or below, and this is more pronounced in the case of the carbon bars. Annealing at 900° causes both the tungsten and the carbon bars to lengthen. The question of hardening cracks is dealt with, and it is shown that for both classes of steel those treatments that produce the highest elastic limit accompanied by the greatest hardness and the finest fracture are frequently the most risky as regards hardening cracks. The tempering of bending-test bars is dealt with, and results and conclusions are given. The preparation and testing of a series of tensile-test bars is described and results given, and it is shown that a variation in the hardening temperature of only 5°, the extremes being above and below Ac 1, 2, 3, has a great influence upon the extension under load, but the max. stress of the bars so treated does not differ much. C. O. B.

396. *Brittleness of Mild Steel due to Nitrogen.* **C. E. Stromeyer.** (Inst. Naval Architects, Trans. 52. pp. 193–198; Discussion, pp. 198–199, 1910.)—The results of some analyses of bad and good steels are given. The author concludes that the percentage of phosphorus + 5 times the percentage of nitrogen should not exceed 0·080 per cent. L. H. W.

397. *Gold Telluride.* **G. Pellini and E. Quercigh.** (Accad. Lincei, Atti, 19. pp. 445–449, Nov. 6, 1910.)—Determinations of the solidifying-points of alloys of Au and Te, obtained by either heating Au and Te together, or adding Te to molten Au, show the formation of only one definite compound, viz., $AuTe_2$, corresponding with the mineral calaverite. Eutectics are observed corresponding to $AuTe_2$ + 12 atoms per cent. Au, and $AuTe_2$ + 47 atoms per cent. Au, these solidifying at 416 and 447° C. respectively. No compound was formed corresponding to the formula Au_2Te, as described by Margottet. [See also Abstract No. 1119 (1909).] W. H. Si.

398. *Silver-Sodium Alloys.* **E. Quercigh.** (Zeitschr. Anorg. Chem. 68. 4. pp. 301–306, Nov. 5, 1910.)—Cooling curves of alloys of this series show that the solidification curve is of peculiar shape. From 0–3 atoms per cent. Na the curve falls rapidly, after which it falls slowly to 85 per cent. Na and then very rapidly to a eutectic point which is not more than 0·1° C. lower than the solidifying-point of Na. There appears to be a tendency for the formation of a compound which dissociates to a high degree in the melt. No definite compounds are formed, and from the absence of the eutectic arrest in the Ag-rich alloys, Ag appears to be capable of dissolving about 18 atoms per cent. Na in the solid state. F. C. A. H. L.

399. *Gases occluded in Copper Alloys.* **G. Guillemin** and **B. Delachanal.** (Comptes Rendus, 151. pp. 881–883, Nov. 14, 1910.)—The compositions of the gases extracted by heating samples of special brass, aluminium, bronze, phosphor bronze and tin to 1000° C. *in vacuo* have been determined with the following results. Forged brasses occlude from 1–86 volumes of gas composed for the most part of H, CO_2 and CO. In sound alloys the gas consists largely of hydrogen (90–100 per cent.) but in castings the proportions of CO_2 and CO and CH_4 become considerable. Cold-worked alloys contain much less gas than sound alloys. The occluded hydrogen has no detrimental effect on the mechanical properties of sound alloys. In bronzes the effect of phosphorus is to diminish the solubility for gases but the phosphor bronzes still occlude small quantities of H, CO_2 and CO. Commercial tin also contains a small amount of gases, again composed mainly of hydrogen. Unlike silver, these metals and alloys do not exhibit the phenomenon of "spitting." F. C. A. H. L.

400. *Cartridge Brass, Rolling Brass, and Electrolytic Copper.* **Grard.** (Rev. de Metallurgie, 6. pp. 1069–1118, Oct., 1909. Metallurgie, 7. pp. 651–658, Oct. 22, 1910. Abstract.)—The author has studied the effect of cold-hardening on the brasses of the first group which consist of one micrographical constituent —the α solid solution of Shepherd—and has shown that every particular set of mechanical properties corresponds with a definite microstructure. Cold-hardening was effected by repeated cold rollings without annealing; its absolute value is difficult to define, but the author has taken the factor $100(S-s)/s$ as a measure of "cold-hardness." ($S=$ original area and s the final area in sq. mm. obtained by a tensile test.) The cartridge brass employed contained 67 Cu and 33 Zn and showed a tensile strength of 32 kg./mm.² and an elongation of 64 per cent. Cold-hardening raises the elastic limit and ultimate stress but lowers the elongation, a cold-hardening of 40 per cent. reducing the elongation to 8 per cent., after which it is approximately constant. The effect on the microstructure is to break up the structure and elongate the grains in the direction of rolling, a cold-hardening of 40 per cent. being detected under the microscope in this way. Annealing samples which had been subjected to various degrees of cold-hardening showed that the temperature at which the first change in mechanical properties occurs, decreases with increase of cold-hardening, otherwise the annealing temperature required to produce certain definite properties is independent of the degree of cold-hardening. Experiments on a 125 per cent. cold-hardened material showed that annealing occurs in five stages—(1) up to 275° C. neither the mechanical properties nor the microstructure is appreciably affected; (2) between 275 and 350° C. the tenacity falls from 62 to 40 kg./mm.² while the elongation rises to 40 per cent. The deformed structure gradually disappears and is replaced by a small, regular crystalline structure; (3) between 350 and 750° C. the elongation gradually rises accompanied by a fall in the tenacity, while the structure increases in size and above 675° assumes enormous proportions; (4) between 750 and 880° complete annealing is attained; the crystals grow to a maximum size and the material attains a max. ductility; (5) above 880° both the tenacity and ductility decrease and the structure becomes similar to the cast structure showing small holes. This phenomenon is generally known as "burning," but the author prefers to call this zone (880–900° C.) the "overheating" zone (*zone de fléchissement*). The exact position of the overheating zone depends upon the impurities present, so that for practical purposes it is advisable not to anneal above 700 to 750° C. Overheated material can be regenerated by subsequent cold-hardening. Material subjected to dynamic cold-hardening (hammering) behaves exactly like the material subjected to static hardening (rolling). The effect of length of heating has also been studied, and the author has shown that at any particular temperature the mechanical properties become constant after the lapse of a certain time, depending on the temperature of annealing. Consequently the same properties can be conferred on cold-hardened brass by varying the time of annealing at different temperatures. In a particular example given the effect produced by completely annealing at 500° C. can be produced in 28 sec. at 650° C. Quenching the alloys from temperatures between 650 and 750° C. in water and oil has practically no effect on the properties. Similar experiments have been carried out on rolling brass containing 90 per cent. Cu and 10 per cent. Zn, and on electrolytic copper, with similar results. The overheating zone for the brass lies above 800° C., and for copper above 700° C.

F. C. A. H. L.

401. *The A2 Point in Chromium Steels.* **H. Moore.** (Iron and Steel Inst., Journ. 81, pp. 268–275; Discussion and Correspondence, pp. 276–286, 1910. Abstracts in Engineering, 89, pp. 794–795, June 17, 1910. Metallurgie, 7. pp. 548–551, Sept. 8, 1910.)—Contains results of an investigation of the critical range curves of steels containing from 0·25 to 6·4 per cent. of Cr. The position of Ac1 is progressively raised by additions of Cr to steel and if sufficient be present (3 per cent.) another critical point occurring at about 770° and below Ac1 is indicated by heating-curves. This change is accompanied by an evolution of heat and is identified with the magnetic change-point, thus being Ac2. The occurrence of Ac2 below Ac1 is held to support the view that Fe_3C is insoluble in β iron. A simple and accurate method of determining the magnetic change-point is given.

C. O. B.

402. *Micrographic Examination of Cast Iron in the "Graphitised" Condition.* **O. Kröhnke.** (Metallurgie, 7. pp. 674–679, Nov. 8, 1910.)—A peculiar decomposition of cast-iron tubes results in their being converted into a soft dull grey or dark brown mass, somewhat similar to graphite, without losing their external shape. The change can be brought about by various means and the converted material can be cut with a knife and has a specific gravity of about 2. A number of tubes of varying composition have been buried in the earth and subsequently examined micrographically in various degrees of conversion. One specimen whose normal composition was: Total carbon 3·81 per cent., graphite 2·96, S 0·097, Mn 0·55, Si 2·33, P 1·350, Fe 91·82 per cent., was converted into a material of the composition: Total carbon 9·85 per cent., graphite 8·83, S 0·518, Mn 1·10, Si 4·25, P 3·60, Fe 68·6 per cent. The results appear to be as follows: (1) Pearlite disappears, but apparently only the ferrite is dissolved from it; (2) the graphite remains but is converted into a peculiar greyish-white or white modification according to the extent of the conversion (Graphitierung); (3) cementite and the phosphide eutectic remain unchanged. White iron containing no graphite does not appear to undergo the change, and the same applies to wrought-iron tubes. It would appear, therefore, that the destruction of the tubes is brought about by electrolytic action set up between the graphite and the other constituents of grey iron.

F. C. A. H. L.

403. *Hardness of Bronzes.* **L. Grenet.** (Comptes Rendus, 151. pp. 870–871, Nov. 14, 1910.)—The author has determined the hardness of two bronzes

containing respectively 15 and 20 per cent. tin after quenching in water followed by annealing at various temperatures, with the following results:—

Treatment.	Brinell Hardness.	
	Bronze No. 1.	Bronze No. 2.
Before treatment	130	split.
Quenched at 750° C. in water	110	170
" " annealed at 100° C. cooled in air	108	172
" " " 200° "	130	238
" " " 250° "	146	228
" " " 400° "	118	186
Annealed at 750° C. cooled in furnace (200° per hour)	104	172

The results show that it is possible to obtain results of considerable practical value by annealing bronzes at low temperatures after quenching. The law for steels connecting the hardness with the highest temperature to which it has been heated in its actual physicochemical state, applies to bronzes and appears to be capable of general application. F. C. A. H. L.

404. *Heat Treatment of High-speed Tools.* **C. P. Berg.** (West. Soc. Engin., Journ. 15. pp. 738–754; Discussion, pp. 755–764, Dec., 1910.)—Gives results of experiments undertaken with a view of establishing a guide as to how rapidly the steel should be heated under the high heat treatment, and of determining at what temperature of heat treatment the max. cutting efficiency occurs. The four steels used for the tests contained 0·56 to 0·7 C, 3·80 to 5·80 Cr, and 8·45 to 15·57 per cent. W. From experiments on heat absorption with specimens of various sizes, it was found that the time for the absorption of heat increases very nearly in proportion to the thickness of the steel. Hardness figures, obtained by the scleroscope, of four specimens are given, each of which had received a preheating to 1400° F. and a final heat-treatment at a temperature of 1750° to 2400° F., from which temperature the specimens were quenched in oil at 100° F. The specimens receiving the max. heat all fused at the ends without exception, and some were considerably softened. Quenching at a temperature of 2150° F. with the lower tungsten steels and 2300° F. with the high tungsten steel was found to give the max. hardness. The life of these treated steels varies considerably, and curves are given showing the relation between temperature and life or durability. It is shown that red-hardness—the property of a steel which enables it to cut metal when the cutting end is dull red-heat—depends to a certain extent on the structure of the steel; a uniform size of crystals without separated hard constituents between them gives a large amount of red-hardness and high durability. C. O. B.

405. *Heat Treatment of Brass.* **G. D. Bengough** and **O. F. Hudson.** (Inst. of Metals, Journ. 4. pp. 92–111; Discussion and Correspondence, pp. 112–127, 1910. Engineering, 90. pp. 447–450; Discussion, pp. 440–441, Sept. 23, 1910.)—Contains results of research on the effects of heat treatment on rolled and drawn 70 : 30 brass of varying size of section and somewhat varying character, as made by different manufacturers. With regard to the effects of various annealing temperatures, it is shown that the best combination of strength and ductility is obtained for annealing temperatures between 600 and 700° C. This is in accordance with the results obtained by previous workers. The 70 : 30 alloy does not appear to have a very well-defined yield-point such as is exhibited in the case of mild steel. The effects of varying the annealing period are found to be even more important than the temperature factor. A temperature only a few degrees below the solidus, if maintained for only half an hour will not seriously burn a piece of pure brass, whereas a temperature nearly 100° C. lower will burn the brass if maintained for a sufficiently long time. Even small quantities of impurity have an important effect in increasing the tendency to burn. The atmosphere of the annealing furnace, whether oxidising or reducing, does not appear to affect to any serious extent the properties of brass. A few determinations of the loss of zinc by volatilisation during the annealing process have been made. This loss is appreciable but is mainly a surface effect and the authors do not consider it to be the cause of burning. The results of tests on the mechanical properties of brass wire at high temperatures are given; these show that the max. stress falls off continuously as the temperature is raised. The elongation and contraction of area, on the other hand, fall off to very low values at temperatures between 300 and 400° C., after which a recovery of ductility occurs, and is practically maintained even at 590° C., the highest temperature employed. The suggestion is made that any handling of the material at a slightly higher temperature than usual may cause a permanent deterioration in its properties. The microstructures of annealed, over-annealed and burnt brass have been studied and new facts as to the crystal-growth in brass at low annealing temperatures have been recorded. The structure of burnt brass closely resembles that of over-annealed brass, with the possible difference that the lead segregates in the crystal boundaries. In the *discussion*, **H. C. H. Carpenter** pointed out that Roberts-Austen had recorded an inversion at about 460° in these alloys, a point which had escaped attention but which he and Edwards had confirmed pyrometrically. C. O. B.

406. *Binary and Ternary Alloys of Cadmium, Bismuth and Lead.* **W. E. Barlow.** (Amer. Chem. Soc., Journ. 32. pp. 1390–1412, Nov., 1910.)—Contains the results of an investigation which includes the redetermination of the thermal diagrams of the Pb-Cd and the Pb-Bi series and the thermal examination of the ternary system Pb-Bi-Cd, with a view of completing the fundamental data necessary for systematic work on the constitution of the quaternary alloys of the Pb-Bi-Sn-Cd series. In every determination 40 gm. of the alloy was used, and, in order to prevent or minimise under-cooling, small portions of cold alloy were added to the main bulk every 15 sec. during the cooling. The temperatures were taken every 15 sec. by means of a mercury thermometer, read by telescope; a stirrer was also used. Tables and diagrams are given of the Pb-Cd and Pb-Bi series. The methods of examination of the ternary system Pb-Bi-Cd and the representation of results are discussed, and tables and diagrams are given showing compositions and temperatures at which three breaks occur during cooling. The ternary eutectic is of the following percentage composition: Pb, 40·2; Bi, 51·65; Cd, 8·15, and has a freezing-point 91·5°, which is the lowest of the four possible ternary eutectic of the four metals Sn, Cd, Pb, Bi, the other three eutectics having the following freezing-points: Sn-Cd-Pb, 145° (Stoffel); Sn-Cd-Bi, 103° (Stoffel); Sn-Pb-Bi, 96° (Charpy). In 16 of the alloys investigated, a transformation-point was noted (in addition to the three freezing-points) at a temperature of approximately 124°, and this subject is now being investigated. C. O. B.

407. *Bar Brass.* **W. v. Moellendorff.** (Zeitschr. Vereines Deutsch. Ing. 55. pp. 23–26, Jan. 7, 1911.)—The author summarises the experiences gained over many years, in the laboratory of the Allgemeine Elekt.-Gesell. at

Oberspree, on the production and properties of brass bars. Two properties are essential for the production of bars: hot malleability, to enable as much extension as possible to be obtained in one operation, and ductility in the cold to facilitate the fashioning of final products and drawing down to small sections. If subsequent machining operations are necessary, *e.g.*, screw-cutting in automatics without lubrication, a third property, that of giving rise to good turnings in the form of scales which leave the tool sharply after the cut, is necessary; this demands the minimum of hardness with a fair degree of brittleness. Commercial brasses consist of mixtures of the solid solutions α (copper-rich) and β. α is brittle when hot and ductile when cold, and predominates in rivet and stamping alloys, while β, which is malleable when hot and brittle in the cold, predominates in forging and screw brasses. The mechanical properties and microstructures of four alloys containing different ratios of copper to zinc between the α and β stages, and in three stages of cold-drawing, are described in detail. The results show that the tenacity, elongation, and hardness of the alloys increase with increasing β-content, and that the tensile strength and hardness stand in direct relationship with the degree of cold-rolling. The contraction of the β-rich alloys is lower than that of the α alloys, indicating better machining properties, which result is actually borne out by practice. The β-rich alloy is the best for constructional purposes, and since it has the lowest resistance, it is also best for electrical conductors. The α alloy finds use because of its ductility in the cold and its adaptability to brazing. The brazing of the β-alloys is difficult on account of the volatility of zinc at high temperatures. Fourteen photomicrographs and five diagrams illustrate the paper. F. C. A. H. L.

408. *Titanium and Metallic Sulphides.* **P. Müller.** (Metallurgie, 7. pp. 587–589, Sept. 8, 1910.)—Titanium forms three sulphides, TiS_2, Ti_2S_3 and TiS, all of which are stable in the air, towards water, hydrochloric acid and dilute sulphuric acid, and are separated by hydrofluoric acid, which exerts a selective solvent action dissolving TiS_2 most easily on warming and not attacking TiS at all. The author has studied the reaction between rutile, nickel or iron sulphide and carbon with the object of preparing sulphur-free titaniferous alloys. Preliminary experiments showed that it was necessary to use a double quantity of rutile, and so great an excess of carbon over the proportions demanded by the equation—

$$5TiO_2 + 8FeS + 10C = Ti_2S_3 + 8(FeTi) + 10CO,$$

that the Fe and part of the Ti formed carbides and gave a sulphur-free product containing about 60 per cent. Ti, 10–15 per cent. Fe and 25–30 per cent. C. Subsequent experiments carried out on larger quantities in an arc furnace showed that while it is possible to obtain Ti alloys free from sulphur, the current consumption is too high to render the method a commercial success. Like Si, Ti acts as a desulphurising agent at high temperatures. F. C. A. H. L.

409. *Nickel-Sulphur System.* **K. Bornemann.** (Metallurgie, 7. pp. 667–674, Nov. 8, 1910.)—The author has continued his work on the above system [Abstract No. 1819 (1908)] special precautions being taken to reduce under-cooling in the Ni-rich alloys to a minimum. The result is a simplification of the diagram; the discontinuity occurring in the first fusion curve at about 2 per cent. S was not verified, consequently the melting-point curve falls regularly from the melting-point of Ni to that of the eutectic at

21·5 per cent. S, and only one series of Ni-rich solid solutions can exist. The limit of solubility of sulphur in Ni in the solid at the eutectic temperature (644° C.) is 0·5 per cent., observed thermally, which agrees with the solubility of 0·2 to 0·8 per cent. at 1000° C. found micrographically. The complicated reactions occurring at the S-rich end of the diagram were confirmed.

F. C. A. H. L.

410. *Solubility of Radio-active Emanations in Liquids.* **R. W. Boyle.** (Roy. Soc. Canada, Trans. 3. Sect. 3. pp. 75–80, 1910.)—The paper deals with a relative determination of the absorption of ThEm by various liquids. The method of experiment was to suck air charged with ThEm through the liquid under investigation and through a testing vessel where the ionisation current was measured and assumed directly proportional to the quantity of emanation in the vessel. The following liquids were found in ascending order as regards solubility: distilled water, sulphuric acid, ethyl alcohol, petroleum. The effect of raising the temperature was to diminish the absorptive power, while in the case of water the presence of a dissolved salt slightly lessened the absorption. Owing to the short period of ThEm the method is not suitable for determining the absolute absorption-coefficient in accordance with Henry's law.

E. M.

411. *Inconstancy of the Solubility-product.* **A. E. Hill.** (Amer, Chem. Soc., Journ. 32. pp. 1186–1193, Oct., 1910. Contribution from the Havemeyer Chem. Lab., New York Univ.)—The solubility of thallous chloride in water at 25° was found to be decreased by the addition of acetic acid from 0·01629 N for pure water to 0·01495 for normal acetic acid, 0·01321 for 2-N acid, and so forth. The solubility of tetramethyl ammonium iodide was decreased from 0·2671 N for water to 0·2586 N for N/4 KOH, 0·2377 N in 0·5325-N KOH, and so forth. In each of these cases the theory of "constant solubility-product" would indicate an increase of solubility, but actually a decrease results, which is probably caused by a diminution of the solvent properties of the water by the increasing proportion of electrolyte which it contains.

T. M. L.

412. *Viscosity of Salt Solutions.* **M. P. Applebey.** (Chem. Soc., Journ. 97. pp. 2000–2025, Oct., 1910.)—The author has carried out a careful investigation of the viscosity of aqueous solutions of lithium nitrate at 0°, 18°, and 25°, the concentrations varying from about N/100 to 8N. The riscometer employed was of the Ostwald type of such a size that the rate of flow of liquid was so slow that Poiseuille's law was obeyed with an error of not more than 1 part in 10,000. Corrections for the surface tension were also introduced. The viscosity curve shows a minimum at a concentration in the neighbourhood of N/3. It is shown by the author that the formula of Grüneisen, $(\eta/\eta_0 - 1)/m = A\alpha + B(1 - \alpha) + Cm$, where m is the molecular concentration, α the degree of ionisation, and A, B, and C are constants, does not hold for very dilute solutions. The author now discusses a method of calculating the viscosity taking into account change in the association of the water owing to the hydration of the ions, and the formula obtained yields a curve of the same form as the experimental one. Assuming the correctness of the equation, the author then calculates the values of the ionic hydration so as to obtain concordance with the experimental numbers, and in this way obtains values which are consistent with the estimates of ionic hydration made by other observers.

A. F.

413. *Viscosity Coefficients of Vapours and their Dependence on the Temperature.* **K. Rappenecker.** (Zeitschr. Phys. Chem. 72. 6. pp. 695–722, 1910. Extract of Dissertation, Freiburg, 1909.)—Using the apparatus of Pedersen [Abstract No. 177 (1908)] the author has determined the viscosity of the vapour of ethyl ether, acetone, methyl acetate, ethyl acetate, ethyl alcohol, chloroform, benzene, and isopentane. The following values of the absolute viscosity were obtained :—

	$\eta_{100^\circ} \times 10^7$	$\eta_{212\cdot5^\circ} \times 10^7$.		$\eta_{100^\circ} \times 10^7$	$\eta_{212\cdot5^\circ} \times 10^7$.
Isopentane ...	885·1	1164	Methyl acetate	1015	1859
Ethyl ether ...	967·1	1284	Ethyl acetate	954·6	1280
Acetone	942·7	1257	Chloroform ...	1807	1660
Ethyl alcohol	1090	1417	Benzene	980·2	1247

As regards the temperature-coefficient, the author finds : For vapours of substances boiling below 100°, the value of n in the expression T^n is about 1·1. T is the absolute temperature of the boiling-point. The author discusses the various formulæ which have been put forward for the viscosity of gases and vapours, and deduces the equation—

$$V_s = 1\cdot16 \times 10^{-7}\,[MT]^{3/4}\,.\left(\frac{1}{\eta\,.\,e^{c'/T}}\right)^{3/n},$$

where V_s is the molecular volume at the boiling-point, T the absolute temperature, c' a constant. This formula is shown to give values for the molecular volume in agreement with the numbers obtained by Kopp. The author has obtained also for the absolute number of molecules in a gm.-molecule the number $6\cdot20 \times 10^{23}$, and since the formula from which this is obtained holds over the whole range of substances, it follows that this number is valid also for these substances. The number agrees with the values obtained by other investigators by different methods. The formulæ for the viscosity at low temperatures are also briefly discussed, and the existing formulæ amplified by a term correcting for the condensation round a molecule. A. F.

414. *Ozone.* V. *Heat Effect of the Decomposition of Ozone.* **A. Kailan and S. Jahn.** (Zeitschr. Anorg. Chem. 68. 3. pp. 243–250, Oct. 12, 1910.)—The authors redetermine the heat developed when ozone is decomposed by soda-lime [see Jahn, Abstract No. 848 (1909)] with a modified apparatus. The oxygen (electrolysis of sulphuric acid) is ozonised in a Siemens and Halske apparatus and passed either into a calorimeter or into a gasometer. The calorimeter is a Dewar jacket which was freshly evacuated every time ; the apparatus were calibrated by means of an electrically heated manganin spiral at various rates of the gas current. The temperature-rise, less than 1° C., is read off by telescope on a Beckmann thermometer, provided with an electric tapping device. In some experiments the soda-lime (catalyst) was replaced by glass wool impregnated with platinum black, which soon became inactive, however, or by an electrically heated Pt-wire. The formerly found value is confirmed. Ozone decomposed at constant volume yields 34,500 cals. per gm.-mol. ; but an error in the reading of the thermometer amounting to 0·001° C. might make a difference of up to 400 cals. ; in the case of the Pt-experiments even of 1000 cals. H. B.

415. *Adiabatic Determination of Heats of Solution of Metals in Acids.* II. *Heat of Dilution of the Acid Solutions.* **T. W. Richards, A. W.**

Rowe, and L. L. Burgess. (Amer. Chem. Soc., Journ. 32. pp. 1176–1186, Oct., 1910. Contribution from the Chem. Lab. of Harvard Univ.)—The heats of dilution of the acids $HCl . 20H_2O$ and $HCl . 8·808H_2O$ to $HCl . 200H_2O$ were found to be 0·556 and 1·330 cals. (2·32 and 5·56 kilojoules) respectively. The heats of dilution of the solutions obtained by the action of these acids on various metals were found to differ considerably from the heats of dilution of the acids themselves, the values being greater for zinc and aluminium and less for cadmium chloride solutions, whilst ferrous chloride showed very slight differences indeed as compared with the acid. The corrected values for the heat of dissolution of 1 gm.-atom of metal in $HCl . 200H_2O$ [compare Abstract No. 1168 (1910) were:—

	Heat of Reaction in 18° Cals.	Heat of Reaction in Kilojoules.
Zinc	36·6	153·1
Aluminium	127·0	531·0
Magnesium	110·2	460·6
Cadmium	17·2	71·9
Iron	20·8	87·0

T. M. L.

416. *Formation and Decomposition of Calcium Cyanamide.* **M. Le Blanc and M. Eschmann.** (Zeitschr. Elektrochem. 17. pp. 20–34, Jan. 1, 1911.)—The determination of the equilibrium of the reaction $CaC_2 + N_2 \rightleftarrows CaN_2C + C$ was attempted in 1906 already, in connection with other cognate experiments. About 8 gm. (max. 12 gm.) of the carbide (generally commercial material of 70 per cent.) was put in a nickel boat and heated with nitrogen in a tubular furnace; the tube was first made of Berlin porcelain, then of quartz, which also gave trouble, and finally of nickel. It resulted that some calcium cyanamide distilled from the hotter portions of the tube to the cooler portions in which it was no longer in contact with carbon. The equilibrium was hence disturbed, and the conditions could not exactly be reproduced; the authors believe, however, in a divariant equilibrium. In order to secure a complete azotation they recommend heating up rapidly to about 1800° C., when the mass melts, and cooling down to 1100° afterwards. H. B.

417. *Equilibrium in the System: Calcium Carbide, Calcium Cyanamide, Carbon, Nitrogen.* **M. de K. Thompson and R. H. Lombard.** (Amer. Acad., Proc. 46. No. 11. pp. 247–270, Nov., 1910. From the Rogers Lab. of Physics, Mass. Inst. of Technology. Metallurgical and Chem. Engin. 8. pp. 617–620, Nov., and pp. 682–684, Dec., 1910.)—The reaction $CaC_2 + N_2 \rightleftarrows CaCN_2 + C$ is studied between 1050° and 1500° C. in a graphite crucible, containing graphite, calcium carbide, and cyanamide, in an Arsem vacuum furnace and an atmosphere of nitrogen. As the protective tubes for the thermo-couple would not stand temperatures above 1200° C., a Wanner optical pyrometer was used and standardised by means of a cylinder of carbon heated in a tubular Heraeus furnace. This furnace was also used for some of the determinations, the Arsem furnace being inconveniently large. Charges of CaC_2 of about 30 gm., sometimes containing $CaCl_2$, were employed. The heat effect of the reaction is much greater at comparatively low temperature, so that it would technically be advisable to bind the nitrogen at as low a temperature as possible. The free energy increase of the reaction, read from left to right, is −6700 cals. at 1100° C. and −1714 cals. at 1450° C.

The relation between temperature and pressure is linear throughout this range. Calcium cyanamide distils already at 1050° C., pure lime at about 1500° C. H. B

418. *Formation of Nitric Oxide in Hydrogen Combustion.* **A. Wolokitin.** (Zeitschr. Elektrochem. 16. pp. 814–826, Oct. 1, 1910. From Dissertation, Karlsruhe, 1910.)—F. Haber and J. E. Coates found (1909) that very little NO was formed when CO was burned in air or in mixtures of oxygen and nitrogen rich in oxygen. The yield was increased by pre-heating the gases and by raising the gas pressure to 5 atmos., up to 5 mols. of HNO_3 per 100 mols. of CO_2. The author makes similar experiments with the hydrogen flame. Very little NO is formed in air. Better yields result in Linde air (half oxygen, half nitrogen by volume); a further increase of the oxygen proportion has little influence. The yield in NO also increases as the pressure is raised; but increasing the pressure beyond 15 atmos. (up to 50) has no further effect. The max. yield corresponds to 3 mols. of NHO_3 per 100 mols. of water, that is to say, a 10 per cent. nitric acid can be obtained by burning hydrogen in a mixture of oxygen and nitrogen. This value agrees nearly with the results of explosion experiments by Finckh and by Pier [see Abstract No. 1713 (1909)], but is considerably lower than the value calculated from equilibrium data. This might be explained by the assumptions that the estimated high temperatures are not really attained, or that the specific heats of the gases are higher than supposed. H. B.

419. *Homogeneous Decomposition of Ozone in the Presence of Oxygen and Other Gases.* **D. L. Chapman** and **H. E. Jones.** (Chem. Soc., Journ. 97. pp. 2463–2477, Dec., 1910.)—H. E. Clarke and Chapman having shown [see Abstract No. 844 (1909)] that the rate of decomposition of ozone on the surface of glass is so slow that it can be neglected, the authors study the decomposition of ozone in the presence of other gases. They use a Brodie ozoniser of thin glass, immersed in sulphuric acid, the inner tube containing mercury. It is found that the presence of oxygen, nitrogen, CO_2, and possibly of water-vapour has no effect on the rate of decomposition of ozone which in these cases seems to be a function of the ozone concentration only, while nitrogen peroxide and chlorine accelerate the decomposition; the catalytic action would, therefore, appear to be rather chemical than physical, and the change to be of the second order, 2 mols. of ozone being in the absence of catalysts converted into 3 mols. of oxygen. The experiments are not quite decisive as to the influence of water-vapour; the presence of water-vapour very slightly accelerated the rate, but at 100° the dry gas was just as stable as the moist, as Warburg had observed. H. B.

420. *Nature of the Decomposition of Oxygenated Water by Light.* **Tian.** (Comptes Rendus, 151. pp. 1040–1042, Dec. 5, 1910.)—Pure distilled water is used for diluting hydrogen peroxide, and the solution is kept 70 cm. below a quartz mercury lamp of the A.E.-G. for 200 volts and 3·5 amps. The decomposition of H_2O_2 is determined by means of titration with potassium permanganate. The lamp is placed a considerable distance above the solution in order to avoid the formation of H_2O_2 from water by ultra-violet light, observed by H. Thiele and by M. Kernbaum. The velocity of the decomposition of the H_2O_2 was practically constant for concentrations of 1, 0·5, 0·2, 0·05 gm. of H_2O_2 per litre; it proved smaller, however, for higher concentrations, 10 and 50 gm. per litre, owing to the absorption of the rays by the

H_2O_2. Yet the reaction seems to be monomolecular, because the solution of H_2O_2 obeys the law of Beer (a layer of solution 2 mm. in thickness has the same absorption spectrum for ultra-violet light as 50 mm. of a solution 25 times more diluted), and because the quantity of H_2O_2 decomposed in the unit of time is independent of the concentration. The decomposition takes place according to $H_2O_2 = H_2O + O$; $2O = O_2$. The catalytic decomposition of H_2O_2 is also monomolecular, that by heat bimolecular. H. B.

421. *Binary Mixtures of some Liquefied Gases.* **B. D. Steele and L. S. Bagster.** (Chem. Soc., Journ. 97. pp. 2607–2620, Dec., 1910.)—The authors have determined the vapour pressures of various mixtures of liquid sulphur dioxide and hydrogen bromide, hydrogen sulphide and hydrogen bromide, and hydrogen sulphide and hydrogen iodide, using a glass spiral manometer. In the case of SO_2 and HBr, and of H_2S and HI, the vapour pressures of the mixtures are intermediate between those of the components, while in the case of H_2S and HBr, the vapour pressure curve exhibits a minimum. In the case of H_2S and HI ideal solutions, to which Raoult's law applies over the whole range of concentrations, are formed. Although in the case of H_2S and HBr a minimum in the vapour pressure-concentration curve occurs, there is no evidence either of ionisation, polymerisation, or combination between the two components. A. F.

422. *The Critical Phenomena of Ether.* **F. B. Young.** (Phil. Mag. 20. pp. 793–828, Nov., 1910.)—The author has made a study of the critical phenomena observed in the case of ether. The ether was carefully purified, except that perhaps the last traces of alcohol may not have been removed. Especial attention was paid to the removal of permanent gas from the observation tubes, the filling of which required very great care. The author discusses fully the different phenomena observed in the neighbourhood of the critical point, and concludes that his experiments favour the retention of the classical theory of Andrews. The study of the opalescent appearance through a small range of temperature leads to the conclusion that the appearance at any given temperature belongs to an equilibrium state, since by arresting the fall of temperature at any point the appearance could be fixed; and, moreover, by raising the temperature slowly an approximate reversal of the appearances could be effected. As regards the influence of gravity on the tube contents, the part played seems to be of a subsidiary character. In these experiments it is essential that the last traces of permanent gas should be removed. Extremely slight traces of such impurity have visibly accentuated the phenomena or delayed the establishment of equilibrium. The intensity of the opalescence depends greatly on the density of the substance, so that any cause which produces a small difference in density will produce visible qualitative effects which are great in proportion to the cause. As to the nature of the opalescence itself, the author's experiments tend to favour the kinetic explanation put forward by Küster, according to whom the opalescence is due to the variation in the temperatures of the individual molecules. The experiments thus far decide the Cagniard-Latour temperature to be the true critical temperature of vaporisation. The author also describes a vapour thermostat by means of which the temperatures can be kept constant to within 0·12° C. at 193–194°. A. F.

423. *Dissociation of Iodine Vapour.* **G. Starck and M. Bodenstein.** (Zeitschr. Elektrochem. 16. pp. 961–966, Nov. 15, 1910.)—The authors have determined the vapour pressure of iodine at different temperatures and have from these determinations calculated the degree of dissociation and the equilibrium constant. The method employed was to enclose a suitable amount of purified iodine in a vessel of quartz glass, which could be maintained at a constant temperature in an electrically heated tube furnace. The quartz glass vessel was connected with a quartz glass manometer [Abstract No. 1810 1909)], the experimental details being fully described in the paper. At each temperature the pressure was measured, the equilibrium point being approached both from the direction of higher and of lower temperatures. From the measurements the value of $K = C_I^2/C_{I_2}$ was calculated, the mean values found being as follows: 800°, 0·129; 900°, 0·492; 1000°, 1·58; 1100°, 4·86; 1200°, 10·2. The constant calculated from the partial pressures was found to be at 800°, 0·0114; 900°, 0·0474; 1000°, 0·165; 1100°, 0·492; 1200°, 1·28. The authors have also applied Nernst's theorem to the measurements, and have obtained the equation—

$$\log K' = -7762/T + 1{\cdot}75 \log T - 0{\cdot}000416T + 0{\cdot}422,$$

which gives good agreement with their experimental results. Taking the chemical constant of molecular iodine as 4, the authors calculate the chemical constant for atomic iodine equal to 2·2. This is the first case where the chemical constant of a monatomic substance has been determined.

A. F.

424. *Empirical Relationship between Volta's Potential Series and the Optical Constants of the Metals.* **A. L. Bernoulli.** (Phys. Zeitschr. 11. pp. 1173–1175, Dec. 8, 1910. Paper read before the Schweiz. Naturforscherversamml., Basel, Sept. 6, 1910.)—When the values of Drude's constant, connecting the polarisation angle with the angle of incidence in the case of metallic reflection, are arranged in order of increasing values, a very distinct parallelism is found with the Volta potential series, especially when the values of Drude's constant divided by the valency of the metal is taken instead of the constant itself. Thus:—

	Na	Mg	Al	Mn	Cd	Zn	Ni	Fe	Co	Pb	H
$\frac{\omega}{n}\cdot 10^5$..............	18	78	98	110	135	150	155	164	188	196	209
e.m.f. (Neumann)	—	1·49	1·28	1·07	0·41	0·76	0·28	0·84	0·28	0·15	—

	Sb	Bi	Cu	Hg	Ag	Pd	Au	Pt
$\frac{\omega}{n}\cdot 10^5$............	227	228	250	278	288	292	303	314
e.m.f...........	—0·18	—0·25	—0·84	—0·78	—0·81	—0·82	—1·11	—0·89

All optical constants refer to yellow monochromatic light. Every potential difference $E_{1,2}$ (difference of the single potential) of pure metals can be represented (empirically) by the formula $E_{1,2} = A(\omega_1/n_1 - \omega_2/n_2)$, where A is a universal constant. From the values for Mg and Au the author calculates $A = 1126$, and $\omega/n_1 = 2{\cdot}094 \times 10^{-3}$. This latter number is the Drude constant for *solid* hydrogen and, further, $E_{\omega=0} = 2{\cdot}860$ is the potential of the hypothetical metal for which the two polarisation angles become identical. In this way a physically defined fixed point for potentials is obtained. The method of the author also allows of determining the valency of the metal.

A. F.

425. *Component Values of the E.M.F. of a Voltaic Cell.* **G. Guglielmo.** (Accad. Lincei, Atti, 19. pp. 572–577, Dec. 4, 1910.)—From thermoelectric experiments with a Daniell cell, using in some cases calorimetric electrodes, consisting of cylindrical zinc vessels completely filled with alcohol and provided with graduated tubes, the level of alcohol in which indicated gain or loss of heat by the electrode, the author concludes that the p.d. between a metal and a solution of its salt is approximately proportional to the heat of combination and solution of a gm.-equivalent of the metal with the electronegative part of the salt, and nearly equal to this heat, expressed in joules, divided by the electrochemical unit of electricity expressed in coulombs. The proportionality and equality become exact when about 0·2 volt is added to the p.d., or the heat necessary to remove the positive electricity from the metal, and that produced by the opposite current, is subtracted from the heat of combination. [See also Abstract No. 178 (1911).] W. H. St.

426. *Potential of the Sodium Electrode.* **G. N. Lewis** and **C. A. Kraus.** (Amer. Chem. Soc., Journ. 32. pp. 1459–1468, Nov., 1910. Contribution from the Research Laborat. of the Mass. Inst. of Technology, No. 61.)—The authors have determined the potential of the sodium electrode by first determining the potential of a sodium amalgam electrode in a solution of NaOH, and then the e.m.f. of a cell of which one electrode is the amalgam and the other metallic sodium, the electrolyte being sodium iodide in ethylamine. The potential of 0·206 per cent. sodium amalgam against normal sodium ion is 2·1525 volts; the difference in potential between sodium and 0·206 per cent. sodium amalgam in a solution of sodium iodide in ethylamine is 0·8456 volt, so that the potential of sodium in a normal solution of sodium ion at 25° is 2·9981 volts against the normal calomel electrode taken as zero. The temperature-coefficient of the second p.d. given above is — 0·0000408 volt per degree. From the Helmholtz equation the heat evolved when one equivalent of sodium dissolves in large quantities of 0·206 per cent. amalgam is 19,790 cals. Methods are described for preparing and keeping pure sodium amalgam and anhydrous ethylamine and of measuring the true potential of the amalgam of an oxidisable metal in aqueous solution. A. F.

427. *Oscillographic Investigation of some Electrolytic Processes.* III. **D. Reichinstein.** (Zeitschr. Elektrochem. 16. pp. 916–944, Nov. 1, 1910.)—[See Abstracts Nos. 291 and 758 (1910).] The author has continued his investigation of the time change of potential in charge and discharge by means of oscillographic record. For the details reference must be made to the original papers, the chief points obtained in the present investigation being the following: It was found that the curve for the decay of a charge on an electrode consists of two parts, a spontaneous and a forced discharge. When these two were separated it was found that the formation of gaseous hydrogen from the products of electrical discharge at polished Pt electrodes is a much more rapid process than the formation of gaseous oxygen under the same conditions. In the case of the anodic solution of a base metal, the energy necessary to get the metal back into solution is greater than that required to effect the deposition; and this loss of energy is all the greater, the greater the current density, *i.e.*, the faster the solution is caused to take place. The potential of anodic solution becomes equal to the equilibrium value only when the current density becomes very small. With interrupted direct current Ni exists in an active and passive state, which are independent of one another. When in the passive state periodic phenomena were observed. The author discusses the reason of rise of potential with current density, and suggests two possibilities, viz., formation of a gas film and formation of atomic groups, which on break of current only slowly pass back into the atomic form. A. F.

428. *Determination of the Ratio between Chlorine and Bromine and Sodium.* **J. S. Goldbaum.** (Amer. Chem. Soc., Journ. 33. pp. 35–50, Jan., 1911. Contribution from the John Harrison Lab. of Chemistry.)—Goldbaum and Smith having shown that a silver anode can be used for accurate determinations of chlorine and bromine in the haloid salts [see Abstract 291 (1911)], the author applies the method to the determination of atomic weights. A Hildebrand cell was employed, with a three-decker Pt-gauze anode, which was silvered in an electrolyte of the double oxalate of silver and ammonium, since this gives a more porous deposit of silver than that obtained from the cyanide electrolyte. When all the chlorine has been deposited the anolyte will still contain a certain amount of silver chloride, owing to the solubility of this substance in water; the amount in solution was accordingly estimated in a Richards' nephelometer and the proper correction applied to the weight of the anode. The usual precautions necessary in atomic weight determinations were taken. The salts used were sodium chloride and bromide. Taking the atomic weight of Na as 23·00, that of Cl was found to be 35·462 ± 0·0005 (11 determinations), and that of bromine 79·927 ± 0·0014 (8 determinations). Since the accepted value for the atomic weight of Na—namely, 23·00—is based on oxygen through either Ag, Cl, or Br, it is better to calculate the atomic weight of Na taking that of Cl as 35·458 and that of Br as 79·920. The result is 22·997 ± 0·0008 from the sodium chloride series, and 22·998 ± 0·0003 from the sodium bromide series. [See Abstracts Nos. 847, 849, 850 (1908).] T. S. P.

429. *Deposition of Zinc from Blende in Fused Electrolytes.* **F. Thomas.** (Metallurgie, 7. pp. 706–710, Nov. 22, 1910.)—The author describes attempts, so far unsuccessful, at electrolysing zinc blende dissolved in fused silicates and sulphides. The melting-points of most silicates were found too high, zinc boiling at 920° C., and K-Na-Mn-orthosilicate melting at 700° dissolved even at 900° only 0·5 per cent. of blende; the yield of the electrolysis (Borchers cells) was very poor, the zinc was very finely distributed, and the electrolysis had to be conducted under high pressure to avoid evaporation of zinc. Separation of zinc by means of iron from a solution of blende fused in Na_2S, FeS failed even at 960°; the operation was carried out under high pressure, but there was still evaporation of zinc, owing probably to local overheating. Electrolysis of a solution of blende in the fused sulphides yielded up to 15 per cent. of zinc, but again in a state of very fine subdivision. The addition of PbS raised the melting-point considerably. H. B.

430. *The Deposition of Metallic Chromium in the Electrolytic Determination of Manganese according to Engels' Method.* **J. Köster.** (Zeitschr. Elektrochem. 17. pp. 57–58, Jan. 15, 1911.)—The bad results obtained by Otin [see Abstract 1889 (1909)] in the electrolytic determination of Mn are due to the fact that he did not follow accurately the method given by Engels, but replaced ammonium acetate by sodium acetate. It is shown that under these conditions the deposit on the kathode contains both Mn and Cr, the latter coming from the chrome alum in the electrolyte. When Engels' directions are carefully followed no deposit forms on the kathode, but there is always the danger that small quantities of chromic acid may remain clinging to the anode deposit and thus affect the results. It is therefore better not to use chrome alum in the electrolyte, but to add alcohol and electrolyse with high current-densities, stirring the electrolyte meanwhile. T. S. P.

431. *Efficiency in the Electrolytic Production of Metallic Calcium.* **F. C. Frary, H. R. Bicknell and C. A. Tronson.** (Amer. Electrochem. Soc., Trans. 18. pp. 117–122; Discussion, p. 123, 1910. Chem. Eng. 12. No. 5. Chem. News, 103. pp. 7–9, Jan. 6, 1911.)—The arrangement of Frary and Badger [see Abstract No. 638 (1910)] is used, comprising an anode crucible of Acheson graphite and an iron rod as kathode, both water-cooled. The chief thing is to provide for a continuous raising of the kathode and for a continuous addition of electrolyte, which requires personal attention. When this is done, an efficiency of 100 per cent. can be reached. To add calcium fluoride to the calcium chloride, as recommended by Ruff and Plato and others, is not advantageous; the mixture melts at 660°, but 750° is the best temperature for the electrolysis, and the bath hence becomes too fluid and the calcium sticks are not solid; the efficiency is rather diminished by using the mixture. H. B.

432. *Electrolytic Separations.* **I. H. Buckminster and E. F. Smith.** (Amer. Chem. Soc., Journ. 32. pp. 1471–1477, Nov., 1910.)—In the following separations the kathode was generally a Pt dish and the anode a rotating Pt spiral. Mercury is readily separated from Ni in a sulphate electrolyte containing free sulphuric acid; the deposits of Hg contain no Ni. Bismuth is similarly separated from Ni, but the deposit of Bi is not coherent. Copper is deposited pure in the presence of Ni from a nitrate electrolyte containing free nitric acid. The same holds for Ag in the presence of Ni when the electrolyte contains alcohol; in the absence of alcohol there is invariably a considerable anodic deposition. From an electrolyte containing Hg as nitrate and Ni as sulphate and free nitric acid, a quantitative deposition of Hg is obtained. Lead is readily separated as peroxide from Ni in nitric acid solution, and Zn from Ni in an alkaline tartrate solution. In an electrolyte containing free phosphoric acid the separation of Cu from Ni is quite satisfactory; in the same electrolyte an attempt to separate Cd from Ni was unsuccessful, the deposited Cd containing Ni. The separation of Hg from Ni in a phosphoric acid electrolyte is also quite good. Nickel is satisfactorily separated from Al in an ammonia-ammonium sulphate electrolyte, if the Ni deposit is afterwards washed with sodium hydroxide in order to remove adherent aluminium hydroxide. In using a similar electrolyte to separate Ni from Fe it was found that ferric hydroxide was apt to contaminate the deposit of Ni. If the sulphate is replaced by some other ammonium salt this electrolyte may also be used to separate Ni from Mg and the alkaline earth metals. In attempting to separate Ni from Cr in the presence of ammonium hydroxide and ammonium sulphate no deposit could be obtained. The addition of potassium chromate to an ammonium hydroxide-ammonium sulphate electrolyte containing Co or Ni entirely prevented the deposition of the latter metals. The solution containing Co went pink in colour, suggesting the presence of cobaltammine, and on the addition of hydrochloric acid a precipitate of purpureocobalt chloride separated on warming. The addition of potassium chromate to an ammoniacal copper solution containing ammonium sulphate prevents the deposition of Cu, whereas it has no effect on an ammoniacal silver nitrate solution; this electrolyte may consequently be used for the separation of Ag and Cu, although it is not preferable to the older methods. Although Au is not deposited from a similar electrolyte containing gold chloride, it cannot be separated from Ag in this way, since the last traces of Ag always carry down some Au. Zinc can be satisfactorily deposited from a cyanide electrolyte under the following conditions: To the zinc solution is added sufficient potassium hydroxide to completely precipitate the Zn as hydroxide, and then enough cyanide to just re-dissolve the precipitate and about 20 c.cm. of ammonium hydroxide, sp. gr. = 0·96. Neither Ni or Co are deposited from a similar electrolyte, but it cannot be used to separate Zn from Ni or Co. From solutions containing Pb and Mn and strongly acid with nitric acid quantitative deposits of lead peroxide are obtained, which only contain traces of Mn. Bismuth may be separated from W and Mo by using a tartrate solution containing free tartaric acid. Silver may be separated from Bi in nitric acid solution if to the latter small quantities of ferric and chrome alum are added. The addition of either of the alums is unnecessary if to 72 c.cm. of a solution containing 0·1–0·2 gm. of Ag and 0·1–0·2 gm. of Bi are added 3 c.cm. of nitric acid and the electrolysis is conducted at 60° with a current density of 0·15–0·20 amp./dm.^{2} at 3 volts. The voltage should be maintained constant and the electrolysis allowed to proceed until the amperage falls to 0·002. Mercury may be separated from Bi from a similar electrolyte, using 1·3 volts. Zinc, Co, or Ni can be satisfactorily separated from uranium in sulphate solution containing free sulphuric acid when a mercury kathode is used. **T. S. P.**

REFERENCES.

433. *Oxidation of Atmospheric Nitrogen by Arc Flames.* **J. Zenneck.** (Phys. Zeitschr. 11. pp. 1228–1233, Dec. 15, 1910. Paper read before the 82. Naturforscherversamml., Königsberg, 1910. Metallurgical and Chem. Engin. 9. pp. 73–75, Feb., 1911.)—A general paper dealing with the processes of Birkeland and Eyde, Pauling, Moscicki, Badische Anilin- und Sodafabrik, and others. Owing to the difficulty of conducting the electrical measurements, little reliance is to be placed on technical efficiency figures. **H. B.**

434. *Theory of Solutions.* **A. A. Jakowkin.** (Zeitschr. Phys. Chem. 70. pp. 158–197, 1910.)—A theoretical paper in which the author suggests that osmotic pressure depends on the association of solvent and solute, and proceeds to show that this is compatible with the fact that the osmotic pressures of dilute solutions may be calculated from the gas-laws. Evidence in support of this theory is quoted from the author's measurements of partial vapour-pressures. **T. M. L.**

435. *Validity of Planck's Formula for Diffusion Potentials.* **N. Bjerrum.** (Zeitschr. Elektrochem. 17. pp. 58–61, Jan. 15, 1911.)—A discussion of the validity of Planck's formula for the diffusion potential between two electrolytes. It is shown that in certain cases it does not hold and can be better replaced by Henderson's formula. An experimental arrangement is given where Planck's formula is valid. **T. S. P.**